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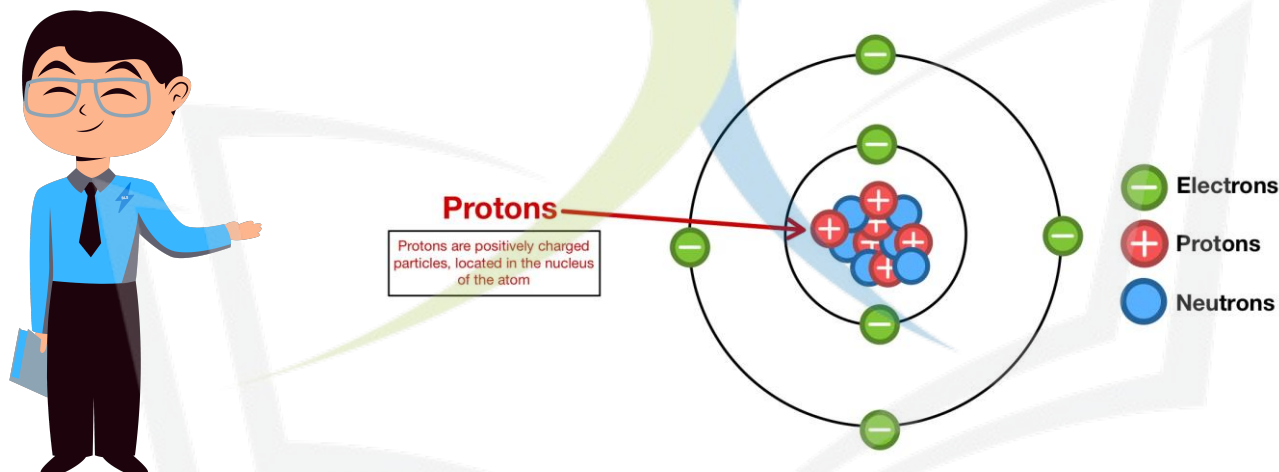
AS PER LATEST CBSE CURRICULUM 2024-25

INTRODUCTION

Discovery of protons

The proton is the positively charged subatomic particle present inside the nucleus of the atom. Proton carries a positive charge.

The mass of the proton is about 1840 times the mass of the electron and its mass is almost equal to the mass of the neutrons. The number of protons inside the nucleus of any atom is called the atomic number and the properties of any element are the periodic function of its atomic number. Generally, the number of protons and the number of electrons for any atom is equal which maintains the electrical neutrality of any atom.



Mass of Proton

As we know that all the mass of any atom is concentrated in the nucleus of the atom as both Protons and Neutrons reside inside the nucleus. The mass of the atom is measured in amu or Atomic Mass Units.

The mass of a proton is $1.6726219 \times 10^{-27}$ kilograms or $1.6726219 \times 10^{-24}$ grams. It is slightly equal to 1 amu.

In 1886 Eugene Goldstein (1850–1930) discovered evidence for the existence of a positively charged particle. Using a cathode ray tube with holes in the cathode, he noticed that the rays were travelling in the opposite direction from the cathode rays. He called these canal rays and showed that they were composed of positively charged particles.

The nucleus of the atom was discovered by Ernest Rutherford in the year 1911 in his famous Gold Foil experiment. He concluded that all the positively charged particles in an atom were concentrated in a singular core and that most of the atom's volume is empty. He also stated that the total number of positively charged particles in the nucleus is equal to the total number of negatively charged

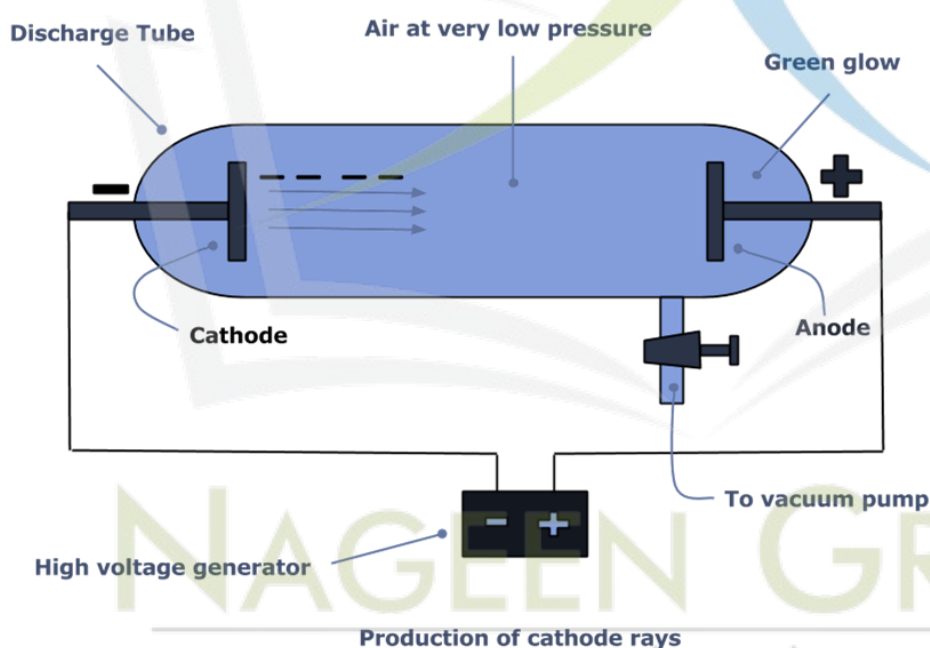
electrons present around it. To support his theory he performed a famous experiment known as the Gold foil experiment.

Discovery of Electron

The electron is a negatively charged, low-mass particle. As a result, passing close to other electrons or the positive nucleus of an atom might readily deflect it. The first basic particle identified was the electron.

J.J. Thomson and The Discovery of Electron

J.J. Thomson, a scientist, began working with cathode ray tubes in the early 1900s. Cathode ray tubes are vacuum-sealed glass tubes that have had most of the air removed. At one end of the tube, a high voltage is placed between two electrodes, causing a stream of particles to flow from the cathode (the negatively charged electrode) to the anode (the positively charged electrode) (the positively charged electrode).



Because the particle beam, or cathode ray, starts at the cathode, the tubes are termed cathode ray tubes. The beam may be detected by painting phosphors on the tube's far end, beyond the anode.

Thomson surrounded the cathode ray with two oppositely charged electric plates to investigate the particles' characteristics. The cathode ray was redirected from the negatively charged electric plate to the positively charged plate.

The cathode ray was made up of negatively charged particles, according to this.

STRUCTURE OF THE ATOM

INTRODUCTION

Thomson also installed two magnets on either side of the tube and noticed that the cathode ray was diverted by the magnetic field. Thomson used the findings of these tests to calculate the mass-to-charge ratio of cathode ray particles, which led to a surprising discovery: each particle's mass was much, much lower than any known atom. Thomson continued his tests with several metals as electrode materials and discovered that the characteristics of the cathode ray were consistent regardless of the cathode material.

Thomson made the following findings based on the evidence:

Negatively charged particles make up the cathode ray.

Because the mass of each particle is $\sim 1/2000$ that of a hydrogen atom, they must be part of the atom.

Within the atoms of all elements, these subatomic particles may be found.

Thomson's discoveries were initially contentious, but they were progressively accepted by scientists. His cathode ray particles were eventually given a more common name: electrons. The discovery of the electron contradicted Dalton's atomic theory's assumption that atoms were indivisible. An altogether new atomic model was required to account for the presence of electrons.



The charge to mass ratio of an electron

The charge to mass ratio of the electron is given by:

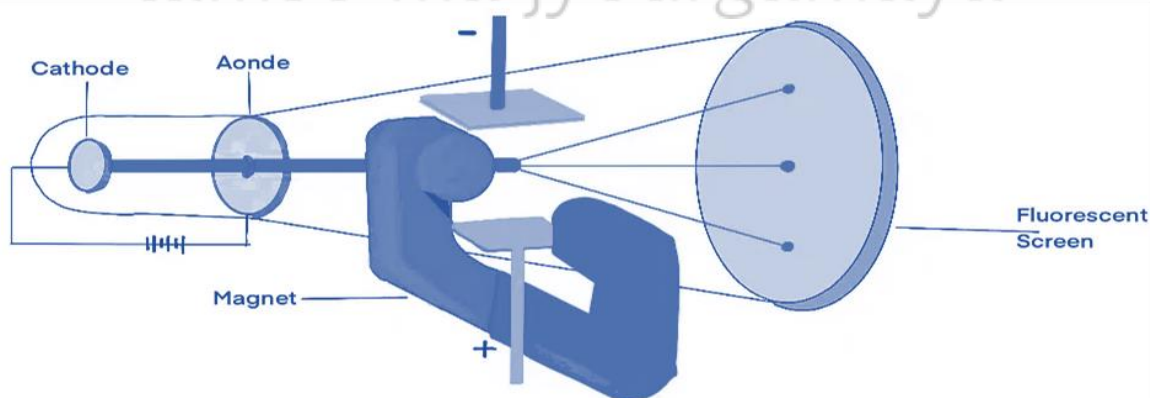
$$e/m = 1.758820 \times 10^{11} \text{ C/kg}$$

Where,

m = mass of an electron in kg = $9.10938356 \times 10^{-31}$ kilograms.

e = magnitude of the charge of an electron in coulombs = 1.602×10^{-19} coulombs.

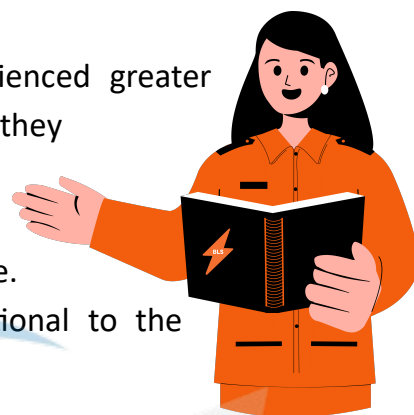
Experimental setup for the determination of charge to mass ratio of the electron



STRUCTURE OF THE ATOM**INTRODUCTION**

While carrying out the discharge tube experiment, Thomson observed that the particles of the cathode deviate from their path. He noticed the amount of deviation in the presence of an electrical or magnetic field depends on various related parameters.

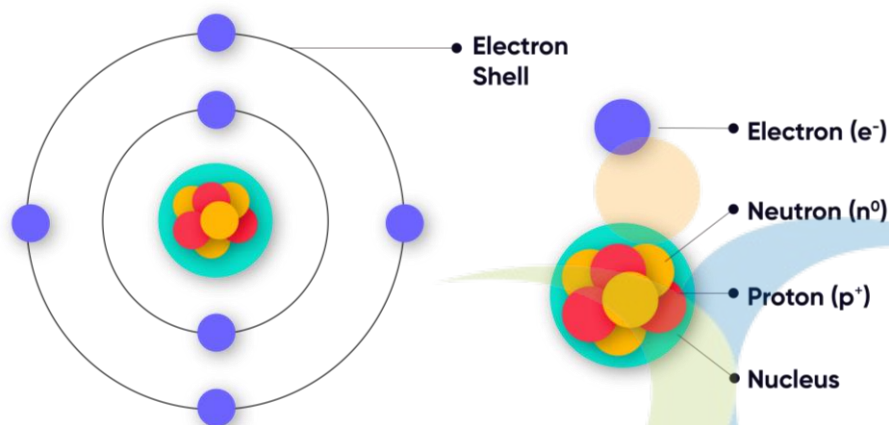
- ❖ Particles with a greater magnitude of the charge experienced greater interaction with the electric or magnetic field. Thus, they exhibited greater deflection.
- ❖ Lighter particles experienced greater deflection. Thus, deflection is inversely proportional to the mass of the particle.
- ❖ Deflection of particle from their path is directly proportional to the strength of the electrical and the magnetic field present.



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STRUCTURE OF THE ATOM**STRUCTURE OF AN ATOM****STRUCTURE OF AN ATOM**

Atoms are tiny particles that comprise all the things in the known universe. Atoms of an element are responsible for all chemical reactions occurring in nature.



Atoms are made up of three fundamental particles namely,

- Electrons
- Protons
- Neutrons

These particles are also called subatomic particles as they are found inside atoms. An atom is the basic building block of matter and all the thing around us is made up of combing atoms in different proportions.

Atoms are the smallest part of an element and between the 18th and 19th centuries, many scientists proposed their theories regarding the structure of atoms based on their studies. These theories were published to elaborate on the structure of atoms, and its constituent.

The most appreciated theories about the atomic model were proposed by,

- John Dalton's Atomic Theory
- J.J Thomson's Atomic Model
- Niels Bohr's Model of an Atom
- Ernest Rutherford's Atomic Model

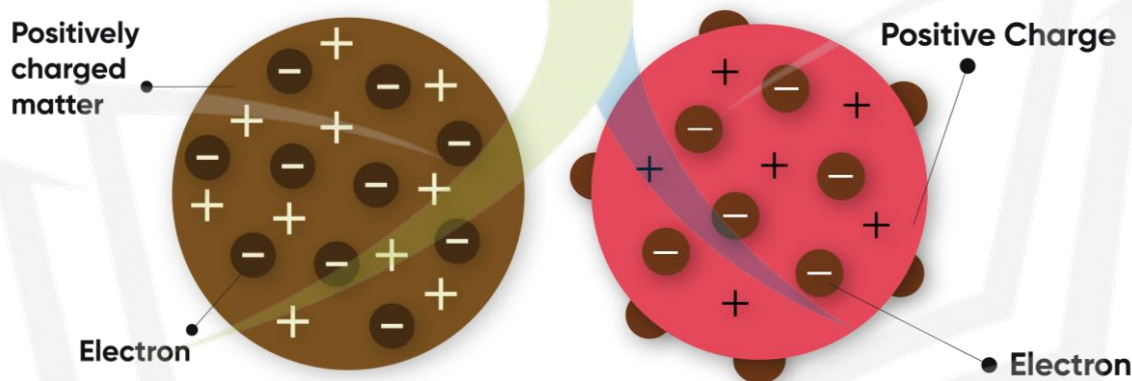
These theories give us an idea about the structure of the atom and the general output of all the theories is that,

“An atom consists of two parts a nucleus which lies at the center and carries a proton (positively charged particle) and neutron (negatively charged particle) and the other part is the outer shell that carries electrons (negatively charged particles). The electrons present in the outer shells continuously revolve around the nucleus without losing any energy.”

STRUCTURE OF THE ATOM**STRUCTURE OF AN ATOM****Thomson's Model of an Atom**

According to Thomson,

- ❖ An atom consists of a positively charged sphere and the electrons are embedded in it.
- ❖ The negative and positive charges are equal in magnitude. So, the atom as a whole is electrically neutral.
- ❖ The first model of an atom to be put forward and taken into consideration.
- ❖ He proposed a model of the atom be similar to that of a Christmas pudding/watermelon.
- ❖ The red edible part of the watermelon is compared with the positive charge in the atom.
- ❖ The black seeds in the watermelon are compared with the electrons which are embedded on it.

**Postulates of Thomson's Atomic Model**

- ❖ An atom consists of a positively charged sphere or cloud in which negatively charged electrons are embedded. The positive charge of the sphere is uniformly distributed to balance the negative charge of the electrons.
- ❖ An atom is an electrically neutral quantity, and the total positive charge of the atom is balanced by the total negative charge in the atom.

Limitations of Thomson's Atomic Model

- ❖ This model did not account for the presence of positively charged particles in the atom, which were later identified as protons by Ernest Rutherford. The model assumed that the positive charge was distributed uniformly throughout the atom.
- ❖ The model could not explain the results of the gold foil experiment conducted by Rutherford, which showed that most of the mass and positive charge of an atom is concentrated in a small, dense nucleus at the centre of the atom.



STRUCTURE OF THE ATOM

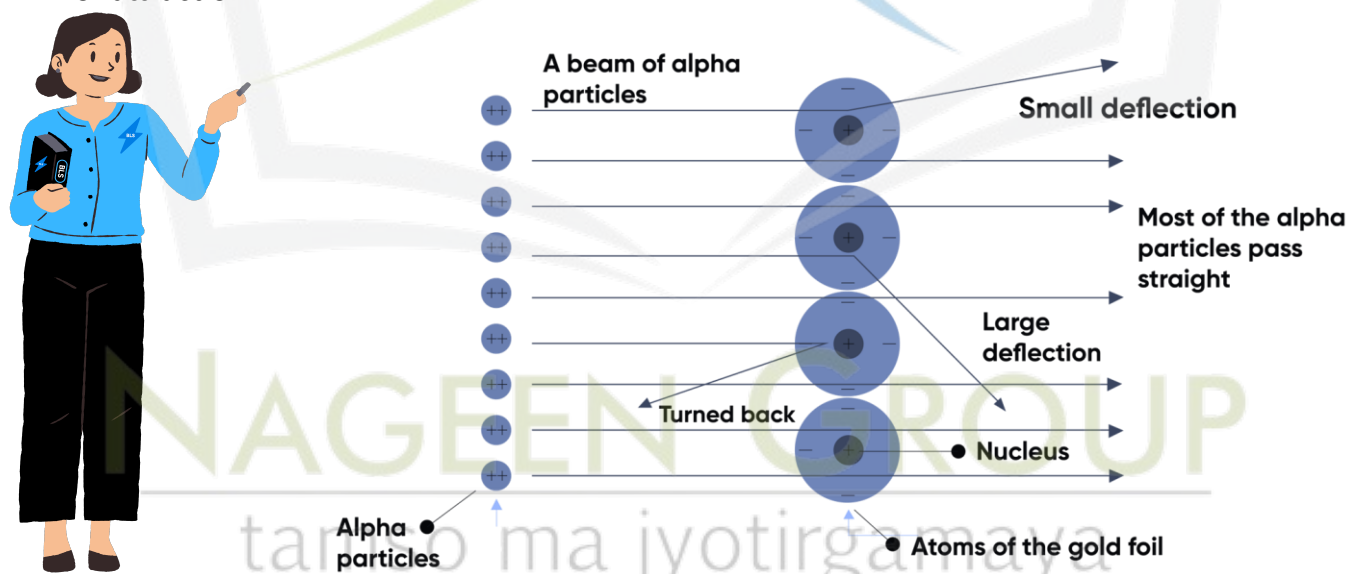
STRUCTURE OF AN ATOM

- ❖ The model could not explain the phenomenon of atomic spectra, which is the emission and absorption of specific wavelengths of light by atoms.
- ❖ The model did not explain the presence of Isotopes.

Rutherford's Model of an Atom

The plum pudding model of J.J. Thomson could not explain certain experimental results about the atomic structure of elements. Still, there was no clear model that defines atoms, therefore in 1909, Ernest Rutherford, a British scientist conducted an experiment and based on the experiment he observed and proposed the atomic structure of elements and Rutherford Atomic Model.

- ❖ The positively charged particle was concentrated in an extremely small volume and most of the mass of an atom was also in that volume. He called this a nucleus of an atom.
- ❖ Rutherford proposed that there are negatively charged electrons around the nucleus of an atom. The electron surrounding the nucleus revolves around it in a circular path with very high speed. He named orbits to these circular paths.
- ❖ Nucleus being a densely concentrated mass of positively charged particles and electrons being negatively charged are held together by a strong force of attraction called electrostatic forces of attraction.

Observations of Rutherford's Alpha Scattering Experiment

- ❖ First, he observes that most of the α -particles that are bombarded towards the gold sheet pass away the foil without any deflection, and hence it shows most of the space is empty.
- ❖ Out of all, some of the α -particles were deflected through the gold sheet by very small angles, and hence it shows the positive charge in an atom is non-uniformly distributed. The positive charge is concentrated in a very small volume in an atom.

STRUCTURE OF THE ATOM**STRUCTURE OF AN ATOM**

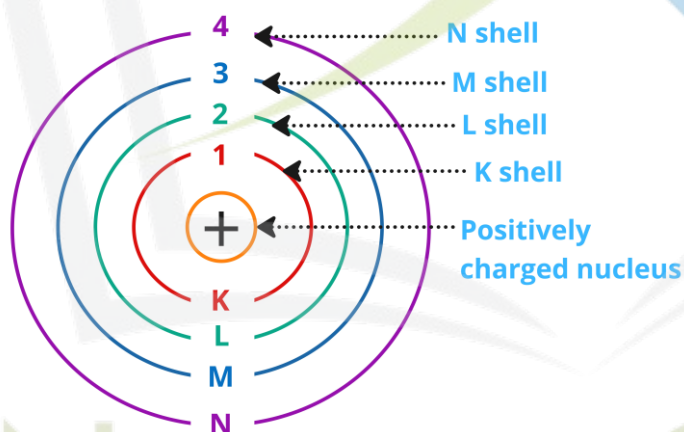
- ❖ Very few of the alpha-particles (1-2%) were deflected back, i.e., only a very less amount of α -particles had nearly 180° angle of deflection. This shows that the volume occupied by the positively charged particles is very small as compared to the total volume of an atom.

Drawbacks of Rutherford Atomic Model

- ❖ He explained that the electrons in an atom revolve around the nucleus in well-defined orbits. Particles in a circular orbit would experience acceleration.
- ❖ Thus, the revolving electron would lose energy and finally fall into the nucleus.
- ❖ But this cannot take place as the atom would be unstable, and the matter would not exist in the form we know.

Bohr's Model of an atom

Bohr's model consists of a small nucleus (positively charged) surrounded by negative electrons moving around the nucleus in orbits where he found out that an electron located away from the nucleus has more energy as compared to electrons close to the nucleus.



Bohr's model of an atom can be described where an atom is made up of three sub-atomic particles – protons, electrons, neutrons. Proton is a positively charged particle that is a fundamental constituent of all atomic nuclei. It is the lightest and most stable and has a charge which is equal in magnitude to that of the electron. An electron is a particle that is a fundamental constituent of matter that exists independently or as the component outside the nucleus of an atom. A neutron is an elementary particle that has no charge, and which has a mass slightly greater than that of a proton. Protons and neutrons are housed in a tiny nucleus at the atom's core.

The electrons spin rapidly around the nucleus in circular routes known as energy levels or shells. The number of electrons that each shell can hold is limited. The formula is, $2n^2$ where n is the orbit number or energy level index.

STRUCTURE OF THE ATOM**STRUCTURE OF AN ATOM**

Each energy level is associated with a fixed amount of energy and there is no change in the energy of the electrons as long as they keep revolving in the same energy level, and the atom remains stable.

Postulates of Bohr's Model of an Atom

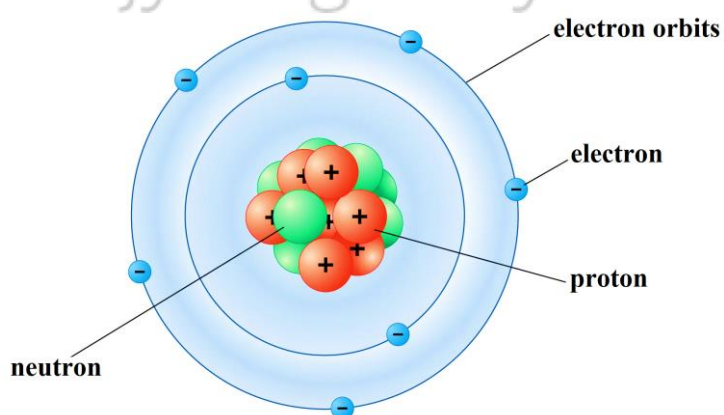
- ❖ Electrons revolve around the nucleus in stable orbits without the emission of radiant energy. Each orbit has a definite energy and is called an energy shell or energy level.
- ❖ An orbit or energy level is designated as K, L, M, and N shells. When the electron is in the lowest energy level, it is said to be in the ground state.
- ❖ An electron emits or absorbs energy when it jumps from one orbit or energy level to another.
- ❖ When it jumps from a higher energy level to a lower energy level, it emits energy, while it absorbs energy when it jumps from a lower energy level to a higher energy level.

Limitations of Bohr's Model of Atom

- ❖ It failed to explain the Zeeman Effect. In the presence of a static magnetic field, the Zeeman effect causes a spectral line to break into numerous components. It's similar to the Stark effect.
- ❖ It also failed to explain the Stark effect. The Stark effect is the splitting of a spectral line into several components in the presence of an electric field.
- ❖ It violated the Heisenberg Uncertainty Principle and couldn't explain the spectra of bigger atoms. This concept asserts that an object's position and velocity cannot be determined precisely at the same time. In fact, in nature, the concepts of absolute position and exact velocity have no relevance.

**Neutron**

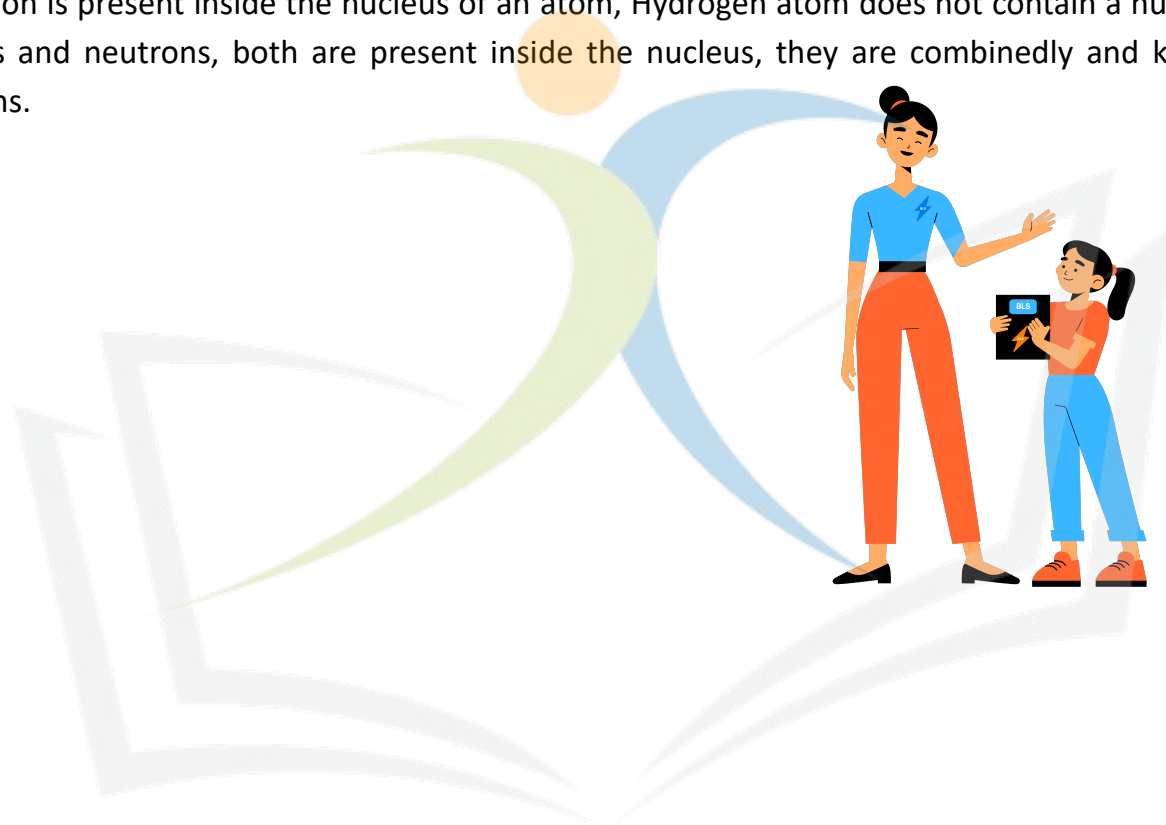
Neutrons are subatomic particles that are one of the primary constituents of atomic nuclei within Electrons and Protons. Neutron, neutral subatomic particle that is a constituent of every atomic nucleus except ordinary hydrogen.



STRUCTURE OF THE ATOM**STRUCTURE OF AN ATOM**

Neutrons and protons are together termed nucleons since they behave in a very similar manner within the nuclei of atoms. The number of nucleons is also called the Mass number. The mass of a nucleon may be roughly approximated to at least one mass unit (often abbreviated to a.m.u.). The branch of science that deals with the study of the properties of neutrons and also the interactions of those subatomic particles with different matter and nonparticulate radiation is named atomic physics.

A neutron is present inside the nucleus of an atom, Hydrogen atom does not contain a nucleus. As protons and neutrons, both are present inside the nucleus, they are combinedly and known as nucleons.



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STRUCTURE OF THE ATOM**DISTRIBUTION OF ELEMENTS IN DIFFERENT ORBITS SHELLS****DISTRIBUTION OF ELEMENTS IN DIFFERENT ORBITS SHELLS**

Orbits are energy shells surrounding the nucleus in which electrons revolve.

Electrons move around Nucleus of an atom in **discrete orbits**.

These are also called **energy levels or shells**.

According to Bohr-bury scheme

According to the Bohr Bury scheme, a system is stable when it has less energy.

Thus, the electrons first occupy the first shell i.e., K which has the lowest energy then go to the second shell i.e. L, then M, N, and so on.

The first shell K shell accommodates 2 electrons, the second shell L shell accommodates 8 electrons, the third shell M shell accommodates 18 electrons, and the fourth shell N shell accommodates 32 electrons.

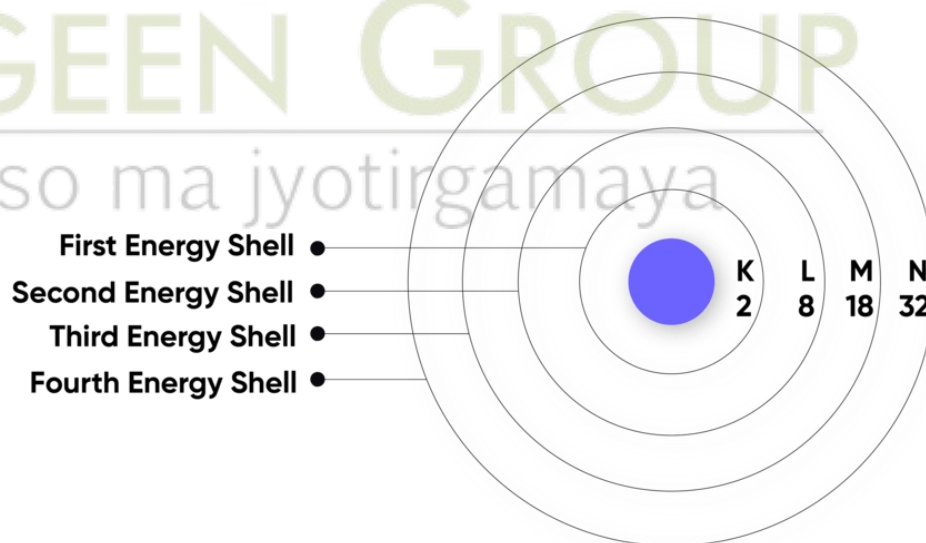
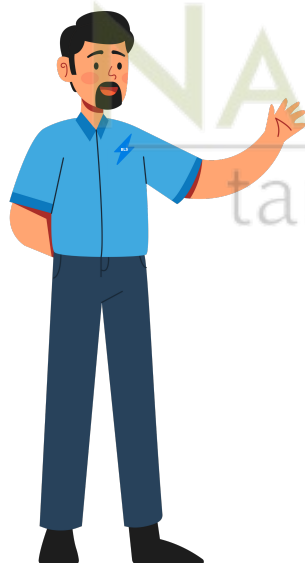
The scheme also states that the outermost shell cannot hold more than 8 electrons.

What is the number of Electrons in a Shell?

The distribution of the electrons in the energy shells is known as electronic configuration.

This is based on the Bohr-Bury scheme according to which, the maximum number of electrons that can be present in a particular energy shell of an atom is given by $2n^2$, where “n” is the number of energy shells.

The energy shells K, L, M, N are the first four energy shells given by Bohr.



So, the maximum number of electrons which can be accommodate in each shell is given as:

STRUCTURE OF THE ATOM

DISTRIBUTION OF ELEMENTS IN DIFFERENT ORBITS SHELLS

Electron Shell	Maximum Capacity
K shell	2 electrons
L shell	8 electrons
M shell	18 electrons
N shell	32 electrons

How is Maximum Number of Electrons in a shell Calculated

For K shell, $n = 1$, using formula $2n^2$, the maximum number of electrons that can be filled in K shell $= 2 \times (1)^2 = 2 \times 1 = 2$.

For L shell, $n = 2$, So number of Electrons $= 2n^2 = 2 \times 2^2 = 2 \times 4 = 8$

For M shell, $n = 3$, So number of Electrons $= 2n^2 = 2 \times 3^2 = 2 \times 9 = 18$

For N shell, $n = 4$, So number of Electrons $= 2n^2 = 2 \times 4^2 = 2 \times 16 = 32$

Examples:

Helium has 2 Electrons: All these are in K Shell (as K Shell can hold max 2 electrons)

HELIUM HAS 2 ELECTRONS



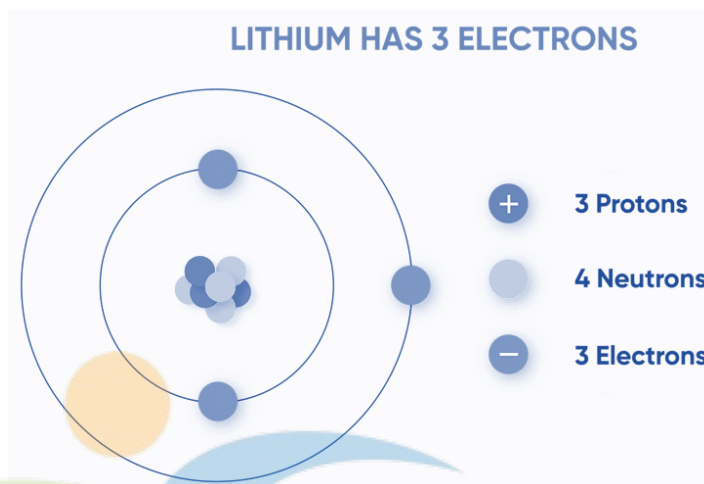
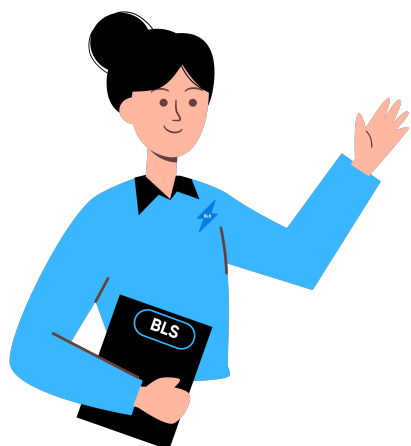
Helium
(2 electrons = 1st orbit)



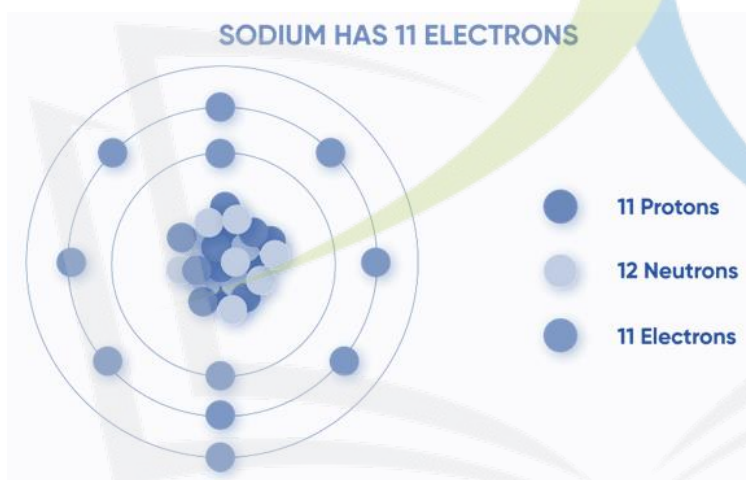
Lithium has 3 Electrons: 2 of these are held in K Shell (as K Shell can hold max 2 electrons), Remaining 1 are held in L Shell

STRUCTURE OF THE ATOM

DISTRIBUTION OF ELEMENTS IN DIFFERENT ORBITS SHELLS



Sodium has 11 Electrons: 2 of this are held in K Shell (as K Shell can hold max 2 electrons), 8 of this are held in L Shell (as L Shell can hold max 8 electrons), Remaining 1 is held in M Shell



Octet Rule

As per the chemical rule of thumb, which is considered to be the octet rule, it is asserted that an electron should have eight electrons in its outermost shell. Moreover, it is seen that this rule is followed by most of the elements from s-block and p-block apart from a few elements from the p block which are known as hydrogen, lithium, and helium. For example, Carbon Dioxide is a compound that follows binding information the 'Octet Rule'. As per the chemical rule of thumb which is the octet rule it is asserted that an electron should have eight electrons in its outermost shell.

The octet rule can be observed in the bonding between the carbon and oxygen atoms in a carbon dioxide molecule, as illustrated via a Lewis dot structure.



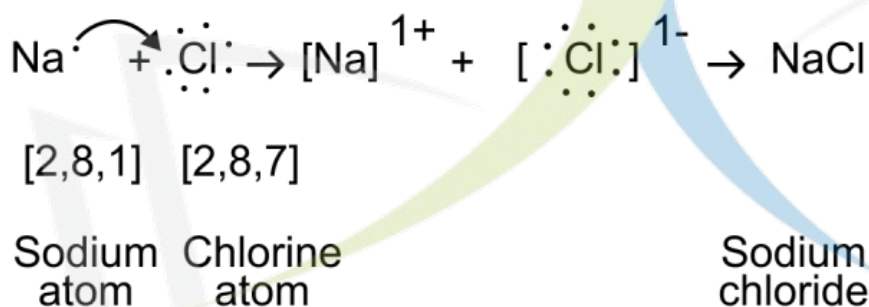
STRUCTURE OF THE ATOM

DISTRIBUTION OF ELEMENTS IN DIFFERENT ORBITS SHELLS

For Example:

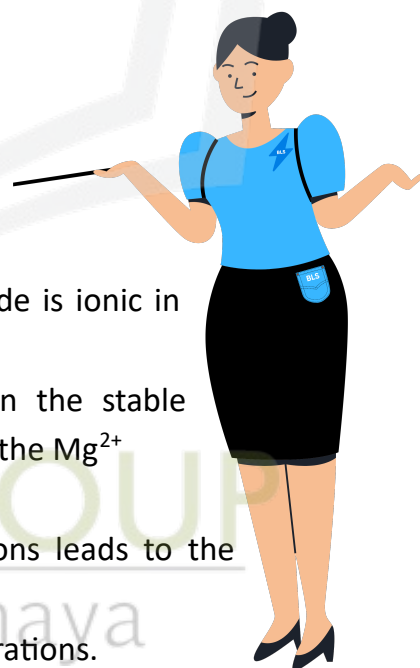
NaCl (Sodium Chloride)

- This compound features an ionic bond between the sodium ion (Na^+) and the electronegative chloride ion (Cl^-).
- The chlorine atom holds 7 electrons in its valence shell and can attain an octet configuration by gaining an electron.
- The outermost shell of sodium has one electron. If it loses this electron, the second shell would become the valence shell (which is already filled with 8 electrons). Thus, the Na^+ ion is more stable than metallic sodium.
- The sodium cation and the chloride anion now form an ionic bond, and the resulting molecule features octet configurations for both the participating atoms.



MgO (Magnesium Oxide)

- The bond between magnesium and oxygen in magnesium oxide is ionic in nature.
- The magnesium atom readily loses two electrons to obtain the stable electronic configuration of neon. This leads to the formation of the Mg^{2+}
- Similarly, oxygen gains two electrons to form the O^{2-}
- The electrostatic attraction that arises between these two ions leads to the formation of an ionic bond between them.
- Both the atoms in a molecule of MgO have stable octet configurations.



VALENCY

The valency of an atom is equal to the number of valence electrons that this atom can gain or lose during chemical reactions. For example, the amount of hydrogen atoms, chlorine atoms, or double the number of oxygen atoms that one atom of an element may combine with is referred to as its valency.

The valency of an element refers to the number of valence electrons in that element that participates in chemical processes. A chemical compound is created when two or more components are combined in a certain mass proportion. A stable compound is formed when one atom of one element unites with a specific number of atoms of another element. All components have different capabilities for mixing.

valency of an element is equal to the number of electrons present in the outermost shell and if it is greater than 4, then the valency of an element is determined by subtracting the total number of electrons present in outermost shell from 8.

Calculation of valency:

Valency of chlorine: The electronic configuration of chlorine = 2, 8, 7.

Since, chlorine has 7 (more than 4) electrons in its outermost shell.

Therefore, valency of chlorine = 8 - number of electrons in outermost shell = $8 - 7 = 1$

Valency of Sulphur: The electronic configuration of Sulphur = 2, 8, 6.

Since, Sulphur has 6 (more than 4) electrons in its outermost shell.

Therefore, valency of chlorine = 8 - number of electrons in outermost shell = $8 - 6 = 2$.

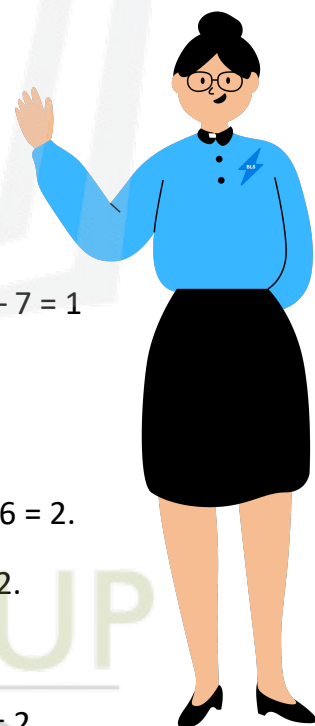
Now, Valency of magnesium: The electronic configuration of Magnesium = 2, 8, 2.

Since, magnesium has 2 (less than 4) electrons in its outermost shell.

Therefore, valency of magnesium = Number of electrons in its outermost shell = 2

Composition on of atoms of first eighteen (18) elements distribution in various shell

Name of Element	Sym bol	Atomic Number	Number of Protons	Number of Neutrons	Number of Electrons	Distribution of Electrons				Vale ncy
						K	L	M	N	
Hydrogen	H	1	1	-	1	1	-	-	-	1
Helium	He	2	2	2	2	2	-	-	-	0
Lithium	Li	3	3	4	3	2	1	-	-	1
Beryllium	Be	4	4	5	4	2	2	-	-	2
Boron	B	5	5	6	5	2	3	-	-	3



STRUCTURE OF THE ATOM

VALENCY

Carbon	c	6	6	6	6	2	4	-	-	4
Nitrogen	N	7	7	7	7	2	5	-	-	3
Oxygen	O	8	8	8	8	2	6	-	-	2
Fluorine	F	9	9	10	9	2	7	-	-	1
Neon	Ne	10	10	10	10	2	8	-	-	0
Sodium	Na	11	11	12	11	2	8	1	-	1
Magnesium	Mg	12	12	12	12	2	8	2	-	2
Aluminium	Al	13	13	14	13	2	8	3	-	3
Silicon	Si	14	14	14	14	2	8	4	-	4
Phosphorus	P	15	15	16	15	2	8	5	-	3, 5
Sulphur	s	16	16	16	16	2	8	6	-	2
Chlorine	Cl	17	17	18	17	2	8	7	-	1
Argon	Ar	18	18	22	18	2	8	8	-	0

Atomic Number and Mass Number

Atomic Number

The number of protons that a chemical element has in its centre (nucleus) is called the atomic number. The mass number is determined by the number of protons and neutrons combined.

Atomic numbers and mass numbers are always whole numbers as they are obtained by counting protons, neutrons, and electrons. The sum of the mass number and the atomic number for an atom corresponds to the total number of subatomic particles present in the atom.

Mathematically, the atomic number is defined as.

Atomic Number (Z) = No of protons (p⁺)

The mass number reports the mass of the atom's nucleus in atomic mass units (a.m.u).

Properties of the Atomic Number:

- The total number of protons in the nucleus of an atom gives us the atomic number of an atom.
- It is represented with the letter 'Z.'
- Atoms of different elements have different atomic numbers. For example, all carbon atoms have the atomic number of 6, whereas all atoms of Oxygen have an atomic number of 8.
- This term was first introduced by Henry Gwyn-Jefferies Moseley.



Mass Number

Rutherford discovered that an atom's nucleus, which is made up of protons and neutrons, contains the vast bulk of its mass. The total number of protons and neutrons in an atom is known as the mass number.

Properties of the Mass Number:

The number of protons and neutrons combined give us the mass number of an atom.

It is represented using the letter 'A.' For example, an atom of carbon has 6 protons and 6 neutrons. Thus, its mass number is 12.

While the number of protons remains the same in all atoms of an element, the number of neutrons can vary. Thus, atoms of the same element can have different mass numbers, and these are called isotopes.

Mathematically, the mass number is defined as.

Mass Number (A) = No. of Protons + No. of Neutrons

Isotopes

Isotopes are variations of the same element with a different number of nucleons. In other words, nuclei with the same number of protons and different numbers of neutrons are classified as isotopes. For example, all carbon atoms contain six protons, but some have 6, 7, or 8 neutrons in the nucleus, which classify these carbon atoms as C-12, C-13, and C-14.

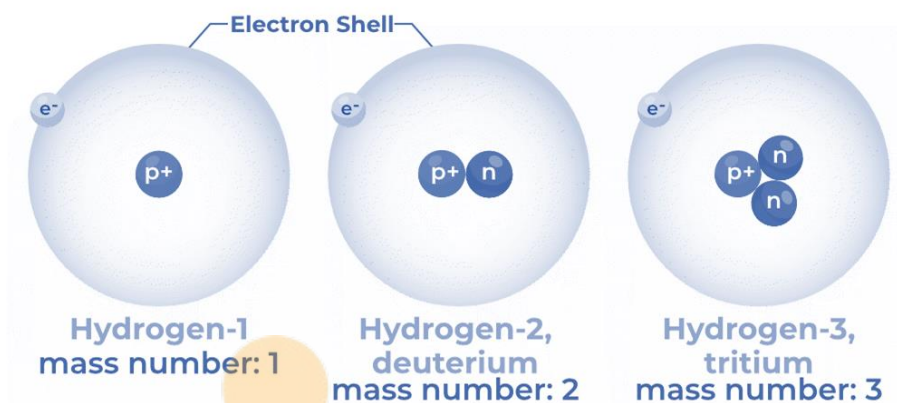
Isotopes of Hydrogen

Hydrogen has three naturally occurring Isotopes. Isotopes of Hydrogen are ${}^1_1\text{H}$ Protium, ${}^2_1\text{H}$ Deuterium, and ${}^3_1\text{H}$ Tritium, but in a lab environment, we can create more isotopes with different numbers of neutrons in the nuclei of it. These synthetic isotopes of Hydrogens are all radioactive and have a half-life of the order of yotta seconds.



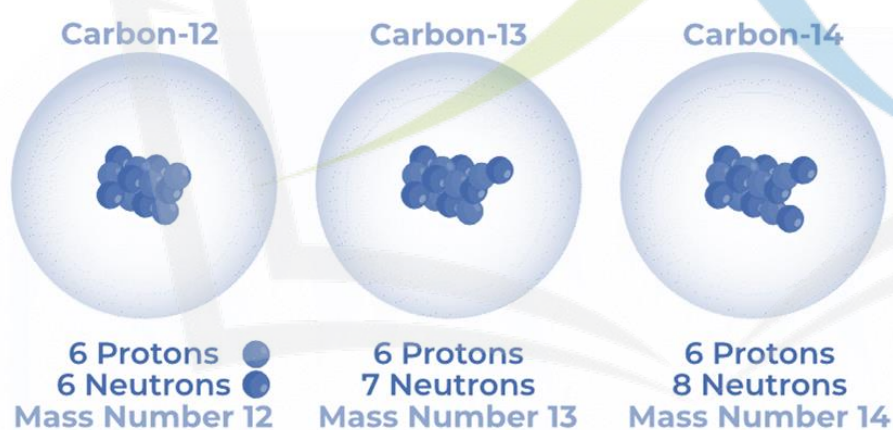
STRUCTURE OF THE ATOM

VALENCY



Isotopes of Carbon

Carbon-13 and Carbon-14 are both isotopes of carbon, one with 7 neutrons and one with 8 neutrons (but both with 6 protons). Carbon-12 is a stable isotope, while carbon-14 is a radioactive isotope (radioisotope). Other than this, many synthetic carbon isotopes are synthesized in a lab environment and can only sustain for a very brief period of time (order of 200 ms).

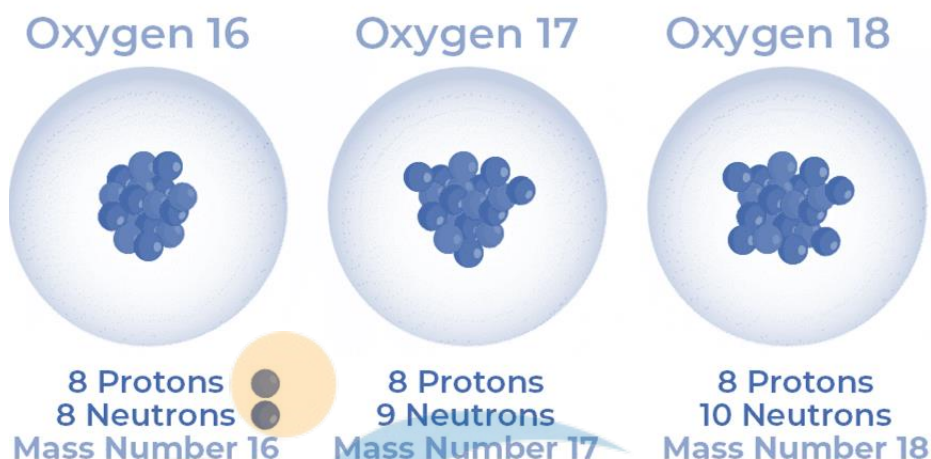


Isotopes of Oxygen

There are only three stable isotopes of oxygen which are ^{16}O , ^{17}O , and ^{18}O . Other than this oxygen nuclei with a different number of neutrons such as 3, 4, 5, 6, 7, etc. can be synthesized in labs but they are not stable in nature and only can exist in the lab environment.

STRUCTURE OF THE ATOM

VALENCY



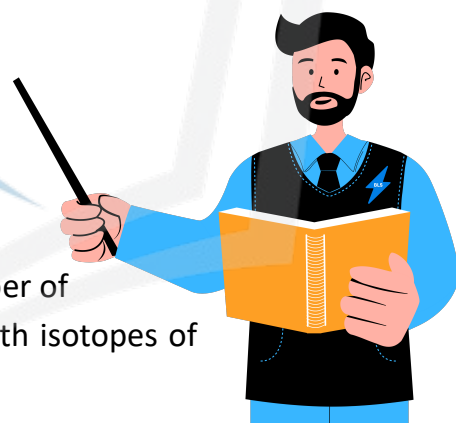
Average Atomic Mass of elements

When an element has an isotope, the mass number can be calculated by the different proportions it exists in.

For example, take 98% Carbon-12u and 2% Carbon-13u

$$\left(12 \times \frac{98}{100}\right) + 13 \times \frac{2}{100} = 12.02\text{u}$$

This does not mean that any Carbon atoms exist with a mass number of 12.02u. If you take a certain amount of Carbon, it will contain both isotopes of Carbon, and the average mass is 12.02 u.

Applications of isotopes

- An isotope of uranium acts as a fuel in nuclear reactors.
- In the treatment of cancer, an isotope of Cobalt is used.
- In the field of medical, an isotope of Iodine is used in the whole-body scan.

Isobars

Isobars are a group of elements from the periodic table that have different atomic numbers, but their mass number are the same. We can say that in isobars the number of protons in their nucleus is different, but the sum of the number of protons and neutrons is the same. For example, Argon ($_{18}\text{Ar}^{40}$), Potassium ($_{19}\text{K}^{40}$), and Calcium ($_{20}\text{Ca}^{40}$) are isobars as they all have 40 as their mass number but their atomic number are different. This happens because they have different atomic numbers but the sum of protons and neutrons in their nucleus is different.

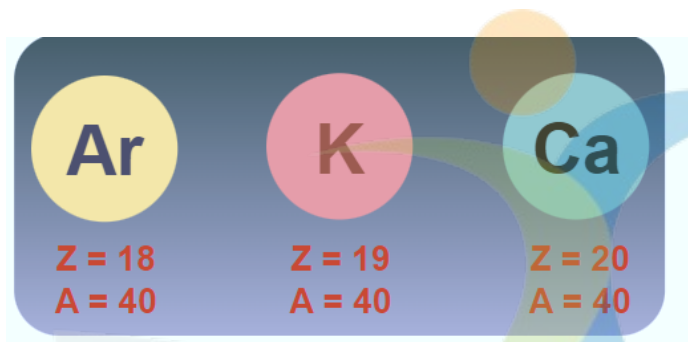
STRUCTURE OF THE ATOM

VALENCY

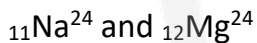
Atom	Atomic Number	Number of Neutrons	Mass Number
Argon (Ar)	18	22	40
Potassium (K)	19	21	40
Calcium (Ca)	20	20	40

The group of Isobar of Argon, Potassium, and Calcium.

Isobar Examples



There are various examples in the periodic table that are isobars, i.e., they have the same mass number but different atomic numbers. Various examples of the isobars are discussed below,



Sodium (24) and Magnesium (24) are the isobars of each other, and we can represent their condition as,

Atom	Atomic Number	Number of Neutrons	Mass Number
Sodium (Na)	11	13	24
Magnesium (Mg)	12	12	24



Aluminium (27) and Silicon (27) are the isobars of each other, and we can represent their condition as,

Atom	Atomic Number	Number of Neutrons	Mass Number
Aluminium (Al)	13	14	27
Silicon (Si)	14	13	27



Sulphur (34) and Chlorine (34) are the isobars of each other, and we can represent their condition as,

STRUCTURE OF THE ATOM

VALENCY

Atom	Atomic Number	Number of Neutrons	Mass Number
Sulphur (S)	16	18	34
Chlorine (Cl)	17	17	34



Iron (58) and Nickel (58) are the isobars of each other, and we can represent their condition as,

Atom	Atomic Number	Number of Neutrons	Mass Number
Iron (Fe)	26	32	58
Nickel (Ni)	27	31	58

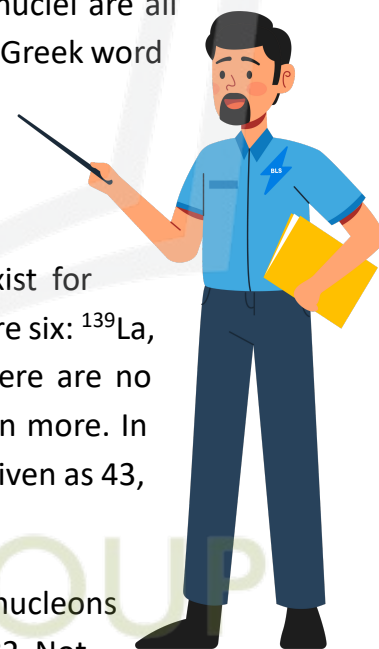
Isotones

Two nuclides are said to be isotones if they contain similar neutron number N , but with different proton numbers Z . For example, carbon-13, and boron-12 nuclei both have 7 neutrons, and so they are called isotones. In the same way, ${}^{37}\text{Cl}$, ${}^{36}\text{S}$, ${}^{39}\text{K}$, ${}^{38}\text{Ar}$, and the ${}^{40}\text{Ca}$ nuclei are all isotones of 20 since they all hold 20 neutrons. About its similarity to the Greek word for "same stretching," the word "isotope" was created by German physicist K. Guggenheimer by changing the letter "p" in "isotope" from "proton" to "neutron."

Observationally, the largest numbers of the stable nuclides there exist for isotones 50 (which are five: ${}^{88}\text{Sr}$, ${}^{86}\text{Kr}$, ${}^{90}\text{Zr}$, ${}^{89}\text{Y}$, and ${}^{92}\text{Mo}$) and 82 (which are six: ${}^{139}\text{La}$, ${}^{138}\text{Ba}$, ${}^{141}\text{Pr}$, ${}^{140}\text{Ce}$, ${}^{144}\text{Sm}$, and ${}^{142}\text{Nd}$). The neutron numbers where there are no stable isotones are given as 19, 21, 35, 39, 45, 61, 89, and 115 or even more. In contrast, the proton numbers, where there are no stable isotopes, are given as 43, 61, and 83 or even more.

This is related to the nuclear magic numbers, which are the number of nucleons that form complete shells within the nucleus. For example, 2, 8, 28, 50, 82. Not more than one stable nuclide contains a similar odd neutron number, except for 1 (it means ${}^2\text{H}$ and ${}^3\text{He}$), 5 (which means ${}^9\text{Be}$ and ${}^{10}\text{B}$), 55 (the ${}^{97}\text{Mo}$ and ${}^{99}\text{Ru}$), and also 107 (the ${}^{179}\text{Hf}$ and ${}^{180}\text{mTa}$). 27 (${}^{50}\text{V}$), 65 (${}^{113}\text{Cd}$), 81 (${}^{138}\text{La}$), 85 (${}^{147}\text{Sm}$), and 105 are the odd neutron numbers of a primordial radionuclide and a stable nuclide (${}^{176}\text{Lu}$). Neutron numbers, where there exist two primordial radionuclides, are given as 88 (${}^{151}\text{Eu}$ and ${}^{152}\text{Gd}$) and 112 (${}^{187}\text{Re}$ and ${}^{190}\text{Pt}$).

For example, boron-12 and carbon-13 nuclei both contain 7 neutrons, and so are isotones. Similarly, ${}^{36}\text{S}$, ${}^{37}\text{Cl}$, ${}^{38}\text{Ar}$, ${}^{39}\text{K}$, and ${}^{40}\text{Ca}$ nuclei are all isotones of 20 because they all contain 20 neutrons.



Structure of the Atom

DPP-01

[Topic: Charged Particles in Matter, The Structure of an Atom]

Very Short Answer Type Questions

1. Name three subatomic particles present in an atom.
2. Name the negatively charged particles present in all the atoms of all the elements.
3. Which part of the atom was discovered by Rutherford's alpha particle scattering experiment?
4. What are Canal rays?
5. If an atom contains one electron and one proton, will it carry any charge or not?
6. Why is an atom neutral inspite of the presence of charged particles in it?
7. How does a proton differ from an electron?
8. Helium atom has atomic mass of $4u$ and has 2 protons in its nucleus. How many neutrons does it have?
9. Who discovered electrons?
10. What is a proton? Who discovered it?
11. What was the main drawback of Rutherford's model of atom?
12. Name an element which does not have any neutron.

Short Answer Type Questions-I

13. Mention any two points which Rutherford put forward to explain the nuclear model of an atom.
14. Compare the properties of electrons, protons and neutrons.
15. What are the limitations of J.J. Thomson's model of the atom?
16. What are the limitations of Rutherford's model of atom?

Short Answer Type Questions-II

17. Describe Thomson's model of atom. Which subatomic particle was not present in Thomson's model of Atom?
18. Describe Rutherford's model of atom.
19. Describe Bohr's model of atom.

Long Answer Type Question

20. Compare all the proposed models of an atom given in this chapter.

Structure of the Atom

DPP-02

[Topic: Distribution of Electrons in Shells, Valency, Atomic Number, Mass Number, Isotopes and Isobars]

Very Short Answer Type Questions

1. The total number of electrons in Nitrogen is 7. What is its valency?
2. What name is given to the pair of atoms: $^{14}_7\text{N}$ and $^{15}_7\text{N}$?
3. Oxygen has 8 protons and 8 neutrons whereas sulphur has 16 protons and 16 neutrons. What is the mass number of oxygen and sulphur.
4. The atomic number of neon is 10. Write its electronic configuration.
5. What happens to the element ' Z ' if it can gain three electrons?
6. Helium has 2 electrons in its valence shell but its valency is not 2. Explain
7. According to Bohr Bury Scheme what is the maximum number of electrons present in M-shell of an atom?
8. In the notation $^{14}_7\text{N}$, what do the numbers 14 and 7 denote?
9. If Mg^{2+} has 12 protons and 12 neutrons, what is its atomic number and mass number?
10. What is the difference between Na atom and Na^+ ion in terms of number of electrons?
11. Why are the shells in which electrons revolve are called energy levels?
12. Why is Co – 60 used in the treatment of cancer?
13. Which isotope is used to find the age of a mummy?
14. Which isotope is used as a fuel in Nuclear reactors?
15. What is the formula of the compound when ' X ' with atomic number 12 combines with an element with atomic number 17?
16. An ion of an element has 3 units positive charge. Mass number of the atom is 27 and the number of the neutrons is 14. What is the number of electrons in this ion?
17. In a sample of ethanoate ($\text{CH}_3\text{COOC}_2\text{H}_5$), the oxygen atoms have the same number of electrons but different number of neutrons. What is a relationship between two atoms of oxygen?
18. Elements with valency equal to one are
 - (a) always metals
 - (b) always metalloids
 - (c) either metals or non-metals
 - (d) always non-metals
19. Which of the following statement is always correct?
 - (a) An atom has equal number of electrons and protons.

- (b) An atom has equal number of electrons and neutrons.
- (c) An atom has equal number of protons and neutrons.
- (d) An atom has equal number of electrons, protons and neutrons.

20. Will ^{35}Cl and ^{37}Cl have different valencies? Justify your answer.

21. Why did Rutherford select a gold foil for his α -ray scattering experiment?

22. One electron is present in the outermost shell of the atom of an element X. What would be the nature and value of charge on the ion formed, if this electron is removed from the outermost shell?

23. In the atom of an element X, 6 electrons are present in the outermost shell. If it acquires noble gas configuration by accepting requisite number of electrons, what would be the charge on the ion so formed?

Short Answer Type Questions-I

24. For the symbol H, D and T tabulate three sub-atomic particles found in each of them.

25. Write the electronic configuration of any one pair of isotopes and isobars.

26. Summarise the rules for writing of distribution of electrons in various shells for the first eighteen elements.

27. Define valency by taking the examples of silicon and oxygen.

28. Na^+ ion has completely filled K and L shells. Explain.

29. If bromine atom is available in the form of, say, two isotopes $^{79}_{35}\text{Br}$ (49.7%) and $^{81}_{35}\text{Br}$ (50.3%).

Calculate the average atomic mass of bromine (Br) atom.

30. The average atomic mass of a sample of an element X is 16.2u. What is the percentage of isotopes $^{16}_8\text{X}$ and $^{18}_8\text{X}$ in the given sample?

31. If $Z = 3$, what would be the valency of the element? Also, name that element.

32. Composition of the nuclei of two atomic species X and Y are given as under

Nuclei	X	Y
Protons	6	6
Neutrons	6	8

Give the mass numbers of X and Y. What is the relation between the two species?

33. The following data represents the distribution of electrons, protons and neutrons in atoms of the elements: A, B, C, D:

Elements	Protons	Neutrons	Electrons
A	19	21	19
B	17	18	17
C	17	20	17
D	18	22	18

Answer the following questions:

- Describe the electronic configuration of B.
- Is element 'B' a metal or a non-metal, why?
- Which two elements are pair of Isotopes?
- Which two elements are pair of Isobars?

34. (a) What is the similarity in the electronic structure of the following set of elements?

- Lithium
 - Sodium
 - Potassium
- (b) Which of the above element is most reactive and why?

35. An atom of an element has two electrons in its outermost 'M' shell, state the (a) electronic configuration, (b) Atomic number, (c) Number of protons, (d) Valency of this element

36. In response to a question, a student stated that in an atom, the number of protons is greater than the number of neutrons, which in turn is greater than the number of electrons. Do you agree with the statement? Justify your answer.

37. Show diagrammatically the electron distributions in a sodium atom and a sodium ion. Give their atomic numbers.

38. In the Gold foil experiment of Geiger and Marsden, that paved way for Rutherford's model of an atom, $\sim 1.00\%$ of the α -particles were found to deflect at an angles $> 50^\circ$. If one mole of α -particles were bombarded on the gold foil, compute the number of α -particles that would deflect at an angle less than 50° .

39. Find the electron distribution for the element that has atomic number 20 and write its valency.

40. If number of electrons in an atom is 8 and number of protons is also 8, then (i) what is the atomic number of the atom? (ii) What is the charge on the atom?

Short Answer Type Questions-II

- Write the distribution of electrons in an atom of element whose atomic number is 18. What is special about the outermost shell of an atom in this element?
- How will you find out the valency of chlorine, sulphur and magnesium atoms?

43. Explain with examples: (i) Atomic number, (ii) Mass number, (iii) Isotopes, (iv) Isobars. Give any two uses of isotopes.
44. State the observations in α -particle scattering experiment that led to Rutherford making the following conclusions:
- Most of the space in an atom is empty.
 - Almost whole of the mass of atom is concentrated in its centre.
 - Centre is positively charged.
45. The number of electrons, protons and neutrons of 5 elements are given below:

Element	A	B	C	D	E
Electron	4	18	17	11	17
Protons	6	18	17	9	17
Neutrons	6	22	20	10	18

- Which of them is a cation?
- Which of them is an anion?
- Which is an atom of inert gas?

46. Fill in the blanks

Element	Atomic Number	P	E	N	Mass Number
Na ⁺	11	11	-	12	23
Ca ²⁺	20	20	18	-	40
Oxygen	8	8	-	8	16

47. In the following table, the mass number and atomic number of certain elements are given.

Elements	A	B	C	D	E	F	G	H
Mass No.	2	3	3	6	9	11	19	23
Atomic No.	1	1	2	3	4	5	9	11

- How many neutrons are present in " F "?
- Which atoms are the isotopes of the same element?

- (c) Which atom will form single positive charged ion?
 (d) Which is an atom of inert gas?
 (e) Which will form single negative charged ion?
 (f) Which one of these have 11 electrons?

48. (a) Calculate the average atomic mass of chlorine if it exists in two isotopes $^{35}_{17}\text{Cl}$ (75%) and $^{37}_{17}\text{Cl}$ (25%).
 (b) Write the main drawback of Rutherford model of atom.

Long Answer Type Question

49. Complete the following table.

Atomic Number	Mass Number	Number of Neutrons	Number of Protons	Number of Electrons	Name of the Atomic Species
9	-	10	-	-	-
16	32	-	-	-	Sulphur
-	24	-	12	-	-
-	2	-	1	-	-
-	1	0	1	0	-

STRUCTURE OF THE ATOM**INTRODUCTION****(Practice Sheet)**

- 1** What is the charge of a proton?
A. Positive
B. Negative
C. Neutral
D. No charge
- 2** Who discovered the proton?
A. J.J. Thomson
B. Ernest Rutherford
C. Eugene Goldstein
D. Dalton
- 3** Who discovered the nucleus of the atom?
A. J.J. Thomson
B. Ernest Rutherford
C. Eugene Goldstein
D. Dalton
- 4** What experiment led to the discovery of the nucleus?
A. Cathode Ray Experiment
B. Gold Foil Experiment
C. Discharge Tube Experiment
D. Dalton's Experiment
- 5** What is the charge of an electron?
A. Positive
B. Negative
C. Neutral
D. No charge
- 6** Who discovered the nucleus of the atom, and what experiment led to this discovery?
- 7** What is the electrical neutrality of an atom dependent on?
- 8** Who observed canal rays and provided evidence for the existence of a positively charged particle?
- 9** What is the charge of the particles making up the cathode ray?
- 10** What does the atomic number represent?

NAGEEN GROUP
tamso ma jyotirgamaya

STRUCTURE OF THE ATOM**STRUCTURE OF AN ATOM****(Practice Sheet)**

- 1 What are the three fundamental particles that make up an atom?**
A. Electrons, Protons, Neutrons B. Photons, Protons, Neutrons
C. Electrons, Positrons, Neutrons D. Electrons, Protons, Isotopes
- 2 Which atomic model proposed a positively charged sphere with embedded electrons, comparing it to a Christmas pudding?**
A. Rutherford's Atomic Model B. Bohr's Model of an Atom
C. Dalton's Atomic Theory D. Thomson's Model of an Atom
- 3 Who conducted the alpha scattering experiment leading to the proposal of the atomic nucleus?**
A. Niels Bohr B. Ernest Rutherford
C. J.J. Thomson D. John Dalton
- 4 What did Rutherford's experiment with alpha particles reveal about the atom?**
A. Electrons are evenly distributed in the atom. B. Most of the atom is empty space.
C. Protons are concentrated in the nucleus. D. Electrons revolve in well-defined orbits.
- 5 Which model of an atom introduced the concept of energy levels or shells for electrons?**
A. Rutherford's Atomic Model B. Thomson's Model of an Atom
C. Bohr's Model of an Atom D. Dalton's Atomic Theory
- 6 Explain the major limitation of Thomson's Model of an Atom.**
- 7 What did Rutherford's observations in the alpha scattering experiment reveal about the structure of an atom?**
- 8 Describe the key postulates of Bohr's Model of an Atom.**
- 9 Why did Bohr's Model fail to explain the Zeeman Effect?**
- 10 How do electrons behave in Bohr's Model when they transition between energy levels?**

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STRUCTURE OF THE ATOM**DISTRIBUTION OF ELEMENTS IN DIFFERENT ORBITS SHELLS****(Practice Sheet)**

- 1** What is the maximum number of electrons that can be accommodated in the K shell according to the Bohr-Bury scheme?
A. 4
B. 8
C. 2
D. 16
- 2** How many electrons can the L shell accommodate according to the Bohr-Bury scheme?
A. 2
B. 8
C. 18
D. 32
- 3** Which compound follows the octet rule in its bonding configuration?
A. NaCl (Sodium Chloride)
B. H₂O (Water)
C. CO₂ (Carbon Dioxide)
D. CH₄ (Methane)
- 4** What is the maximum capacity of the N shell according to the Bohr-Bury scheme?
A. 2 electrons
B. 8 electrons
C. 18 electrons
D. 32 electrons
- 5** What type of bond is formed between the sodium ion (Na⁺) and the chloride ion (Cl⁻) in NaCl (Sodium Chloride)?
A. Covalent bond
B. Metallic bond
C. Ionic bond
D. Hydrogen bond
- 6** What is the maximum number of electrons that can be held in the M shell?
- 7** If an atom has 3 energy shells, how many electrons can be accommodated in the third shell according to the Bohr-Bury scheme?
- 8** According to the octet rule, how many electrons should an atom ideally have in its outermost shell for stability?
- 9** In the Bohr-Bury scheme, which shell has the lowest energy?
- 10** Who is elements violates the octet rule?

tamso ma jyotirgamaya

STRUCTURE OF THE ATOM

VALENCY

(Practice Sheet)

- 1 How is the valency of an element determined if it has more than 4 electrons in its outermost shell?
 - A. Subtracting the number of electrons from 4
 - B. Adding the number of electrons to 4
 - C. Subtracting the number of electrons from 8
 - D. Adding the number of electrons to 8
- 2 Which element has a valency of 2 with the electronic configuration 2, 8, 6?
 - A. Carbon
 - B. Nitrogen
 - C. Oxygen
 - D. Sulphur
- 3 How is the atomic number defined mathematically?
 - A. Atomic Number (Z) = No of neutrons (n)
 - B. Atomic Number (Z) = No of protons (p+)
 - C. Atomic Number (Z) = No of electrons (e-)
 - D. Atomic Number (Z) = No of isotopes (I)
- 4 What is the mass number of an atom?
 - A. The sum of protons and electrons
 - B. The sum of neutrons and electrons
 - C. The sum of protons and neutrons
 - D. The sum of atomic and mass numbers
- 5 What are isotopes?
 - A. Elements with the same number of protons but different neutrons
 - B. Elements with the same number of protons and neutrons
 - C. Elements with the same atomic and mass numbers
 - D. Elements with the same valency
- 6 Explain the difference between atomic number and mass number.
- 7 What is the valency of Chlorine with an electronic configuration of 2, 8, 7?
- 8 Which element has three naturally occurring isotopes, including Protium, Deuterium, and Tritium?
- 9 What is valency, and how is it determined for an element?
- 10 Define isotones and provide an example.

EXEMPLAR SOLUTION

Chapter 4 Structure of the atom

Multiple Choice Questions

1. Which of the following correctly represent the electronic distribution in the Mg atom?

- (a) 3, 8, 1
- (b) 2, 8, 2
- (c) 1, 8, 3
- (d) 8, 2,

2 Soln:

Answer is 2, 8,

2 Explanation :

Atomic number of Mg is 12 hence electronic distribution will be $1s^2 2s^2 2p^6 3s^2$.

2. Rutherford's 'alpha (α) particles scattering experiment' resulted in to discovery of

- (a) Electron
- (b) Proton
- (c) Nucleus in the atom
- (d) Atomic mass

Soln:

Answer is (c) Nucleus in the

atom **Explanation:**

Rutherford's 'alpha (α) particles scattering experiment' experiment concludes that alpha particles returned to their original path. This showed the presence of nucleus in the centre.

3. The number of electrons in an element X is 15 and the number of neutrons is 16. Which of the following is the correct representation of the element?

- (a) $^{31}_{15}\text{X}$
- (b) $^{31}_{16}\text{X}$
- (c) $^{16}_{15}\text{X}$
- (d) $^{15}_{16}\text{X}$

Soln:

Answer is (a) $^{31}_{15}\text{X}$

X Explanation:

Number of protons in an element depicts atomic number. Number of protons and electrons are equal in an element. Hence atomic number is written in subscript whereas mass number is written in the subscript before the symbol of the element.

4. Dalton's atomic theory successfully explained

- (i) Law of conservation of mass
 - (ii) Law of constant composition
 - (iii) Law of radioactivity
 - (iv) Law of multiple proportion
- (a) (i), (ii) and (iii)
 - (b) (i), (iii) and (iv)
 - (c) (ii), (iii) and (iv)
 - (d) (i), (ii) and (iv)

Soln:

Answer is (d) (i), (ii) and (iv)

Explanation:

Dalton's theory explains Law of conservation of mass, Law of constant composition, Law of multiple proportion. But it never give any details of Law of radioactivity .

5. Which of the following statements about Rutherford's model of atom are correct?

- (i) considered the nucleus as positively charged
 - (ii) established that the α -particles are four times as heavy as a hydrogen atom
 - (iii) can be compared to solar system
 - (iv) was in agreement with Thomson's model
- (a) (i) and (iii)
 - (b) (ii) and (iii)
 - (c) (i) and (iv)
 - (d) only (i)

Soln:

Answer is (a) (i) and (iii)

Explanation:

Positively charged alpha particles were deflected by nucleus. This shows nucleus is positively charged. Rutherford also postulated that electrons are arranged in an atom around the nucleus like planets arranged around sun.

6. Which of the following are true for an element?

- (i) Atomic number = number of protons + number of electrons
- (ii) Mass number = number of protons + number of neutrons
- (iii) Atomic mass = number of protons = number of neutrons
- (iv) Atomic number = number of protons = number of electrons

- (a) (i) and (ii)
- (b) (i) and (iii)
- (c) (ii) and (iii)
- (d) (ii) and (iv)

Solution:

Answer is (d) (ii) and (iv)

Explanation:

Atomic number Z is the number of proton present in an electron which is also equal to number of electron in an atom. Since the mass of neutron is negligible. Number of protons and electron are added to obtain mass number of an element.

7. In the Thomson's model of atom, which of the following statements are correct?

- (i) the mass of the atom is assumed to be uniformly distributed over the atom
- (ii) the positive charge is assumed to be uniformly distributed over the atom
- (iii) the electrons are uniformly distributed in the positively charged sphere
- (iv) the electrons attract each other to stabilise the atom

- (a) (i), (ii) and (iii)
- (b) (i) and (iii)
- (c) (i) and (iv)
- (d) (i), (iii) and (iv)

Soln:

Answer is (a) (i), (ii) and (iii)

Explanation:

Thomson proposed that negatively charged electron are stabilised by positively charged protons in the nucleus. Hence option (ii) the positive charge is assumed to be uniformly distributed over the atom is wrong statement and other statements are part of Thomson's model of atom.

8. Rutherford's α -particle scattering experiment showed that

- (i) electrons have negative charge
 - (ii) the mass and positive charge of the atom is concentrated in the nucleus
 - (iii) neutron exists in the nucleus
 - (iv) most of the space in atom is empty Which of the above statements are correct?
- (a) (i) and (iii)
 - (b) (ii) and (iv)
 - (c) (i) and (iv)
 - (d) (iii) and (iv)

Soln:

Answer is (b) (ii) and (iv)

Explanation:

An atom consists of a positively charged, dense and very small nucleus which have all the protons and neutrons. Positive charge is due to protons, as neutrons have no charge. Here the space is empty because alpha particles pass straight through the gold foil without any deflection.

Thomson explained that electrons have negative charge. Existence of neutron was discovered by Chadwick.

9. The ion of an element has 3 positive charges. Mass number of the atom is 27 and the number of neutrons is 14. What is the number of electrons in the ion?

- (a) 13
- (b) 10
- (c) 14
- (d) 16

Soln:

Answer is (b) 10

Explanation:

Mass number (A) of the atom = 27

Number of neutron in the atom = 14

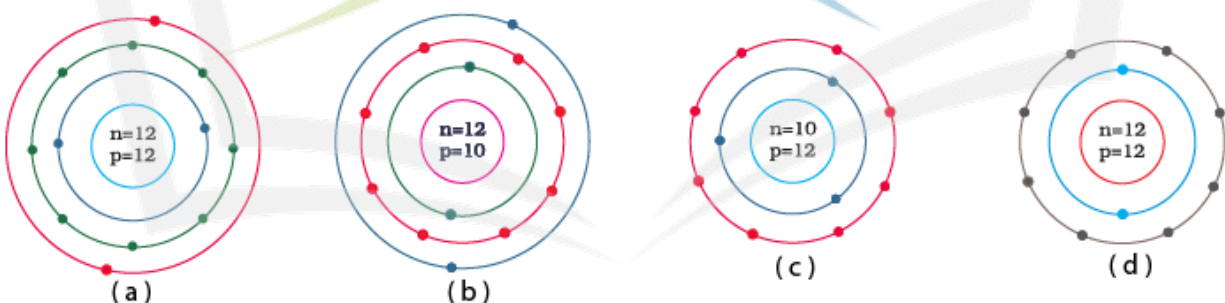
Number of Electrons = Mass number - Number of neutrons = $27 - 14$

Number of electrons = 13

Since ions of the element has 3 positive charges number of electron in the ion is $13 - 3$ which equal 10.

Hence the answer is 10

10. Identify the Mg^{2+} ion from the Fig.4.1 where, n and p represent the number of neutrons and protons respectively.



Soln:

Answer is d)

Explanation:

Number of protons in Mg atom = $2 + 8 + 2 = 12$

Number of neutrons in Mg atom = $24 - 12 = 12$

[as mass number of Mg atom = 24 and number of neutrons = mass number – number of protons]

Therefore, option (d) is the correct answer

11. In a sample of ethyl ethanoate ($\text{CH}_3\text{COOC}_2\text{H}_5$) the two oxygen atoms have the same number of electrons but different number of neutrons. Which of the following is the correct reason for it?

- (a) One of the oxygen atoms has gained electrons
- (b) One of the oxygen atoms has gained two neutrons
- (c) The two oxygen atoms are isotopes
- (d) The two oxygen atoms are isobars.

Soln:

Answer is (c) The two oxygen atoms are isotopes

Explanation:

Two Oxygen atoms in $\text{CH}_3\text{COOC}_2\text{H}_5$ can have different number of neutrons only if the two O-atoms are isotopes. Isotopes of an element have same number of protons (and electrons) but different number of neutrons.

12. Elements with valency 1 are

- (a) always metals
- (b) always metalloids
- (c) either metals or non-metals
- (d) always non-metals

Soln:

Answer is (c) either metals or non-metals.

Explanation:

If element shows positive valency it is a metal and if the element shows negative valency it will be a non-metal.

13. The first model of an atom was given by

- (a) N. Bohr
- (b) E. Goldstein
- (c) Rutherford
- (d) J.J. Thomson

Soln:

Answer is (d) J.J. Thomson

14. An atom with 3 protons and 4 neutrons will have a valency of

- (a) 3
- (b) 7
- (c) 1
- (d) 4

Soln:

Answer is (c) 1

15. The electron distribution in an aluminium atom is

- (a) 2, 8, 3
- (b) 2, 8, 2
- (c) 8, 2, 3
- (d) 2, 3, 8

Soln:

Answer is (a) 2, 8, 3

Explanation:

Atomic number of Aluminium is 13, First shell can have maximum of 2 electron and second shell holds a maximum of 8 electrons. Hence option a is right answer.

16. Which of the following in Fig. 4.2 do not represent Bohr's model of an atom correctly?



- (a) (i) and (ii)
- (b) (ii) and (iii)
- (c) (ii) and (iv)
- (d) (i) and (iv)

Soln:

Answer is ii and iv

Explanation :

First shell can have maximum of 2 electron and second shell can have maximum of 8 electron hence ii and iv do not represent Bohr's model of an atom correctly.

17. Which of the following statement is always correct?

- (a) An atom has equal number of electrons and protons.
- (b) An atom has equal number of electrons and neutrons.
- (c) An atom has equal number of protons and neutrons.
- (d) An atom has equal number of electrons, protons and neutrons.

Soln:

Answer is (a) An atom has equal number of electrons and protons.

Eplanation:

An atom is electrically neutral because the number of protons are always equal to number of electrons. Hence option a) is right.

18. Atomic models have been improved over the years. Arrange the following atomic models in the order of their chronological order

- (i) Rutherford's atomic model
- (ii) Thomson's atomic model
- (iii) Bohr's atomic model
- (a) (i), (ii) and (iii)

- (b) (ii), (iii) and (i)
(c) (ii), (i) and (iii)
(d) (iii), (ii) and (i)

Soln:

Answer is (c) (ii), (i) and (iii)

Explanation:

Thomson's atomic model was proposed in the year 1904

Rutherford's atomic model was proposed in the year 1911

Bohr's atomic model was proposed in the year 1913

Short Answer Questions

19. Is it possible for the atom of an element to have one electron, one proton and no neutron. If so, name the element.

Soln:

Yes, Hydrogen is the element which is having only 1 proton and 1 electron and no neutron hence there is no repulsive force in the nucleus hence it is stable.

20. Write any two observations which support the fact that atoms are divisible

- Ionic compounds are formed because of formation of ions that involves transfer of electrons.
- Difference in the number of make isotopes. This shows that atom is formed by different particles such as electrons, protons and neutrons and element is divisible.

21. Will ^{35}Cl and ^{37}Cl have different valencies? Justify your answer.

Soln:

^{35}Cl and ^{37}Cl cannot have different valencies because they are the isotopes of same element.

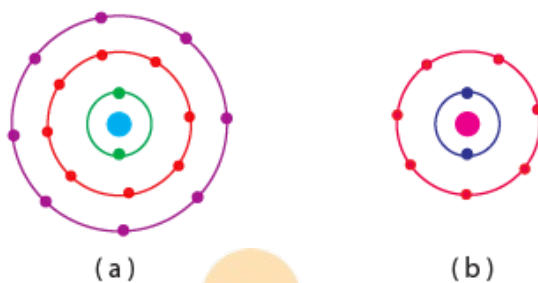
22. Why did Rutherford select a gold foil in his α -ray scattering experiment?

Soln:

Rutherford used gold for his scattering experiment because gold is the most malleable metal and he wanted the thinnest layer as possible.

Therefore, Rutherford selected a Gold foil in his alpha scattering experiment.

23. Find out the valency of the atoms represented by the Fig. 4.3 (a) and (b).



Soln:

Atom (a) has zero valency as it has 8 electron in its valence shell making the configuration stable.
Atom (b) has valency of +1 as it has 7 electrons in its outermost shell. It can accept 1 electron to achieve octet configuration.

24. One electron is present in the outer most shell of the atom of an element X. What would be the nature and value of charge on the ion formed if this electron is removed from the outer most shell?

Soln:

If an electron is removed from the outermost shell a cation will be formed and the charge of the element will be +1.

25. Write down the electron distribution of chlorine atom. How many electrons are there in the L shell? (Atomic number of chlorine is 17).

Soln:

Atomic number of chlorine atom = 17

So, its electronic configuration is

K L M

2 8 7

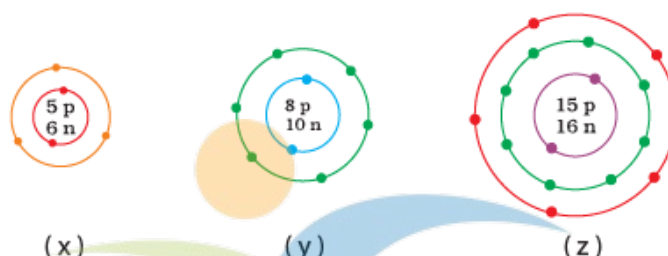
L shell of chlorine contains 8 electrons.

26. In the atom of an element X, 6 electrons are present in the outermost shell. If it acquires noble gas configuration by accepting requisite number of electrons, then what would be the charge on the ion so formed?

Soln:

In this atom 6 electrons are already present in its outermost orbitals. In order to attain noble gas configuration element has to accept two electron hence its charge is -2.

27. What information do you get from the Fig. 4.4 about the atomic number, mass number and valency of atoms X, Y and Z? Give your answer in a tabular form.



Soln

Atomic number, mass number and valency of atoms X, Y and Z

	Atomic no	Mass no	Valency
X	5	11	3
Y	8	18	2
Z	15	31	3.5

28. In response to a question, a student stated that in an atom, the number of protons is greater than the number of neutrons, which in turn is greater than the number of electrons. Do you agree with the statement? Justify your answer.

Soln

Statement is wrong because number of protons can never be greater than number of neutrons. Number of protons will always be less than or equal to number of neutrons. Number of electrons and protons are always equal in a neutral atom.

29. Calculate the number of neutrons present in the nucleus of an element X which is represented as ${}_{15}^{31}\text{X}$

Soln:

Mass number = No. of protons + No. of neutrons = 31

∴ Number of neutrons = 31 – number of protons

= 31 – 15

= 16

30. Match the names of the Scientists given in column A with their contributions towards the understanding of the atomic structure as given in column B

- (A)
- (a) Ernest Rutherford
 - (b) J.J.Thomson
 - (c) Dalton
 - (d) Neils Bohr
 - (e) James Chadwick
 - (f) E. Goldstein
 - (g) Mosley

- (B)
- (i) Indivisibility of atoms
 - (ii) Stationary orbits
 - (iii) Concept of nucleus
 - (iv) Discovery of electrons
 - (v) Atomic number
 - (vi) Neutron
 - (vii) Canal rays

Soln:

- (A)
- (a) Ernest Rutherford
 - (b) J.J.Thomson
 - (c) Dalton
 - (d) Neils Bohr
 - (e) James Chadwick
 - (f) E. Goldstein
 - (g) Mosley

- (B)
- (iii) Concept of nucleus
 - (iv) Discovery of electrons
 - (i) Indivisibility of atoms
 - (ii) Stationary orbits
 - (vi) Neutron
 - (vii) Canal rays
 - (v) Atomic number

31. The atomic number of calcium and argon are 20 and 18 respectively, but the mass number of both these elements is 40. What is the name given to such a pair of elements?

Soln:

Elements with different atomic numbers but same mass numbers are known as isobars. Calcium and argon are isobars.

32. Complete the Table 4.1 on the basis of information available in the symbols given below

(a) $^{35}_{17}\text{Cl}$ (b) $^{12}_6\text{C}$ (c) $^{81}_{35}\text{Br}$

Element	n_p	n_n

Soln:

Element	n_p	n_n
Cl	17	18
C	6	6
Br	35	46

33. Helium atom has 2 electrons in its valence shell but its valency is not 2, Explain

Soln:

Helium has 2 electrons in its outermost shell thereby completing duplet configuration. Hence it has no valence shell left empty making its valency 0.

34. Fill in the blanks in the following statements

(a) Rutherford's α -particle scattering experiment led to the discovery of the _____

(b) Isotopes have same _____ but different _____.

(c) Neon and chlorine have atomic numbers 10 and 17 respectively. Their valencies will be _____ and _____ respectively.

(d) The electronic configuration of silicon is _____ and that of sulphur is _____

Soln:

(a) Rutherford's α -particle scattering experiment led to the discovery of the **atomic nucleus**

(b) Isotopes have same **atomic number** but different **mass number**

(c) Neon and chlorine have atomic numbers 10 and 17 respectively. Their valencies will be **0** and **1** respectively.

(d) The electronic configuration of silicon is **2.8.4** and that of sulphur is **2.8.6**

35. An element X has a mass number 4 and atomic number 2. Write the valency of this element?

Soln:

Mass number = 4

Atomic number = 2

X is Helium.

It has 0 valency and it will not react with any other atom because it has its outer shell filled.

Long Answer Questions

36. Why do Helium, Neon and Argon have a zero valency?

Soln:

Helium has 2 electron in its outermost orbit thus filling shell 1 and forming duplet configuration in valence shell. Neon has 8 electron in their valence orbit hence completing duplet configuration. In the same way Argon and Neon has 8 electron in its outermost shelling completing octet configuration. As these elements have maximum electron in their valence shell thus reach stable electron configuration and they will not take part in any sort of chemical reactions.

37. The ratio of the radii of hydrogen atom and its nucleus is $\sim 10^5$. Assuming the atom and the nucleus to be spherical,

(i) What will be the ratio of their sizes?

(ii) If atom is represented by planet earth ' R_e ' = 6.4×10^6 m, estimate the size of the nucleus.

Soln:

Assuming the atom and the nucleus to be spherical.

(a) Atomic size is represented in terms of atomic radius, $\frac{r_H}{r_n} = 10^5$

As volume of sphere = $\frac{4}{3} \pi r^3$, therefore, $V_H = \frac{4}{3} \pi r_H^3$ and $V_n = \frac{4}{3} \pi r_n^3$

Thus, the ratio of volumes $\frac{V_H}{V_n} = \frac{\frac{4}{3} \pi r_H^3}{\frac{4}{3} \pi r_n^3} = \frac{r_H^3}{r_n^3} = \left(\frac{r_H}{r_n}\right)^3 = (10^5)^3 = 10^{15}$

(b) $\frac{V_n}{V_H} = 10^{-15}$ or $V_n = 10^{-15} \times V_H$

If atom is represented by planet earth with $R_e = 6.4 \times 10^6$ m

Then, volume of atom (V_H) = $\frac{4}{3} \pi R_e^3 = \frac{4}{3} \times 3.14 \times (6.4 \times 10^6 \text{ m})^3$
 $= 1097.5 \times 10^{18} \text{ m}^3 = 1.0975 \times 10^{21} \text{ m}^3$

$\therefore$ Volume of nucleus = $10^{-15} \times (1.0975 \times 10^{21}) \text{ m}^3$
 $= 1.0975 \times 10^6 \text{ m}^3$

38. Enlist the conclusions drawn by Rutherford from his α -ray scattering experiment.

Soln:

Rutherford drawn following conclusion from his α -ray scattering experiment.

- α -particles passed through the gold foil without any deflection concluding the empty space inside the atom.
- Deflection is observed in few particles which proves positive charge of the atom occupies very little space.
- Deflection in A very small fraction of α -particles indicates that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

39. In what way is the Rutherford's atomic model different from that of Thomson's atomic model?

Soln:

Rutherford proposed that electron revolve around the nucleus in well differentiated orbits. Nucleus is the centre which is positively charged. Rutherford proposed that nucleus is very small and nearly all the mass of an atom is centred in the nucleus.

Thompson proposed that electron are scattered positively charged spheres like a Christmas pudding and the mass of the atom was supposed to be uniformly distributed.

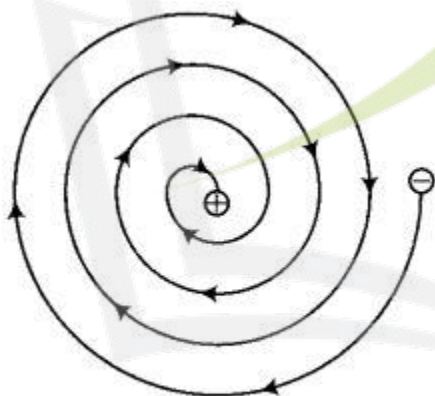
40. What were the drawbacks of Rutherford's model of an atom?

Soln:

Rutherford's model could not explain the stability of the atom.

Revolving electrons would lose energy as they are the charged particles and due to acceleration, charged particles would radiate energy.

Orbit of the revolving electron will reduce in size, following a spiral path as shown in figure and ultimately the electron should fall into the nucleus. In other words, the atom should collapse.



Continuous loss of energy by a revolving electron

41. What are the postulates of Bohr's model of an atom?

Soln:

Postulates of Bohr's model of an atom are

- (i) Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.
- (ii) While revolving in discrete orbits the electrons do not radiate energy. These orbits or shells are called energy levels. These orbits or shells are represented by the letters K,L,M,N,... or the numbers, $n=1,2,3,4,\dots$

42. Show diagrammatically the electron distributions in a sodium atom and a sodium ion and also give their atomic number.

Soln:

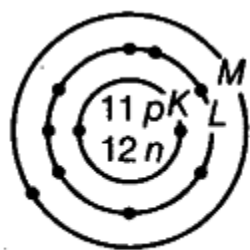
Atomic number of sodium (Z) = 11 Mass number of sodium (A) = 23

Number of protons in the nucleus = 11 Number of neutrons in the nucleus = $23 - 11 = 12$

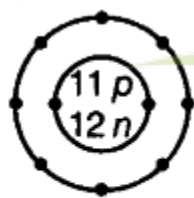
Number of electrons = 11

Electronic configuration of Na-atom = 2, 8, 1(K,L,M)

Na^+ ion is formed from sodium atom by loss of an electron (present in the outermost shell). Hence, its electronic configuration is 2, 8(K,L). However, number of protons and neutrons remains the same.



Sodium atom



Sodium ion

43. In the Gold foil experiment of Geiger and Marsden, that paved the way for Rutherford's model of an atom, ~ 1.00% of the α -particles were found to deflect at angles $> 50^\circ$. If one mole of α -particles were bombarded on the gold foil, compute the number of α -particles that would deflect at angles less than 50° .

Soln:

Total number of α particles used for bombardment = 1 mole

1 mole = 6.022×10^{23} particles

number of α particles deflected at angles greater than $50^\circ (> 50^\circ) = 1\%$

Number of α particles deflected at angles greater than $50^\circ = 100 - 1 = 99\%$

Actual number of α particles deflected at angles less than $50^\circ = \frac{99}{100} \times 6.022 \times 10^{23}$

$= 5.96 \times 10^{23}$

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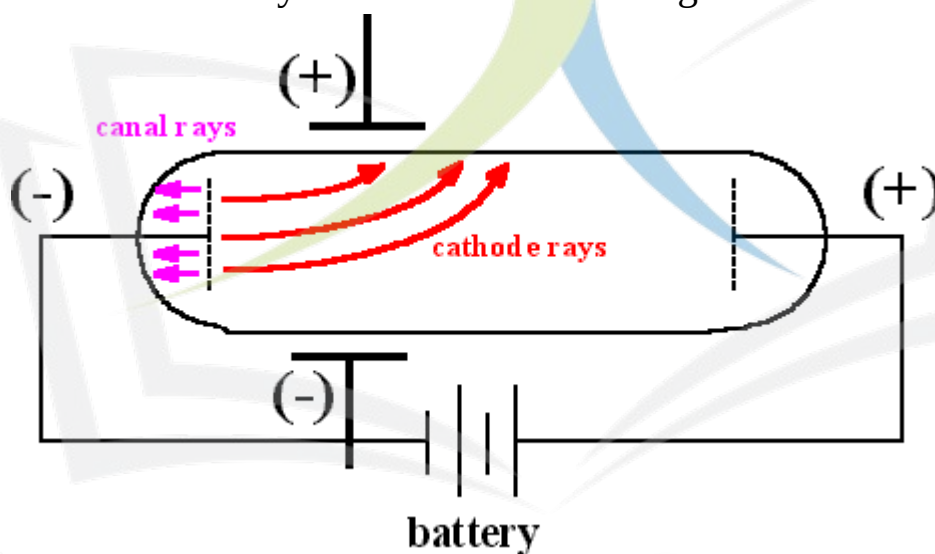
Chapter 4 Structure of the Atom

Questions:

Q. 1 What are canal rays?

Ans:

- The positively charged radiations produced in the discharged tube at low pressure and high voltage are called as canal rays.
- It was noticed by German scientist 'Eugen Goldstein'.



Q.2 If an atom contains one electron and one proton, will it carry any charge or not?

Ans: One proton has one unit positive. Similarly, one electron has one unit negative charge. An atom with one proton and one electron will be electrically neutral. The charges will be balanced inside an atom.

Questions:

Q. 1 On the basis of Thomson's model of an atom, explain how the atom is neutral as whole.

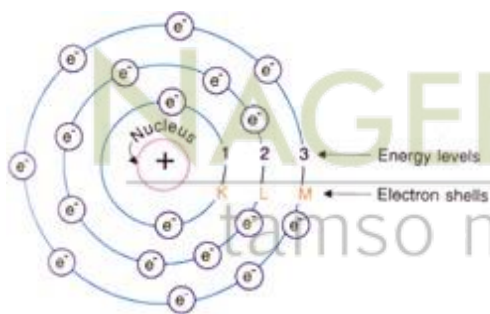
Ans: On the basis of Thomson's model of an atom, an atom consists of a positively charged sphere. The electrons are embedded in the sphere. The negative and the positive charges are equal in magnitude. Hence, the atom is electrically neutral.

Q.2 On the basis of Rutherford's model of an atom, which subatomic particle is present in the nucleus of an atom?

Ans: According to the Rutherford's model of an atom, there is a positively charged center called nucleus. The subatomic particles called protons are embedded in the nucleus. Almost all the mass of an atom resides in the nucleus. The electrons revolve around the nucleus in well defined orbits.

Q.3 Draw a sketch of Bohr's model of an atom with three shells.

Ans: A sketch of Bohr's model of an atom with three electron shells is shown below:



According to Bohr's model of an atom:

- (i) Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.
- (ii) While revolving in discrete orbits the electrons do not radiate energy.

These orbits are called energy levels. Energy levels in an atom are shown by circles.

These orbits are represented by the letters K,L,M,N,... or the numbers, $n=1,2,3,4,\dots$

Further, the distribution of electrons into different orbits of an atom was suggested by Bohr and Bury. The following rules are the rules followed for writing the number of electrons in different energy levels or shells: (i) The maximum number of electrons present in a shell is given by the formula $2n^2$, where 'n' is the orbit number or energy level index, 1,2,3,... Hence the maximum number of electrons in different shells can be written as : first orbit or K-shell will be $= 2 \times 1^2 = 2$, second orbit or L-shell will be $= 2 \times 2^2 = 8$, third orbit or M-shell will be $= 2 \times 3^2 = 18$, fourth orbit or N-shell will be $= 2 \times 4^2 = 32$, and so on. The maximum number of electrons that can be accommodated in the outermost orbit is 8. Electrons are not accommodated in a given shell, unless the inner shells are filled. That is, the shells are filled in a stepwise manner.

Q. 4 What do you think would be the observation if the α -particle scattering experiment is carried out using a foil of a metal other than gold?

Ans: On using any other metal other than gold would not have affected the observations of the experiment. Since, the structure of an atom is same for all states of atom. All other metals are not as ductile as gold, so a thin foil would have been difficult to obtain. If a thick foil is used in this experiment, then more alpha particles would have bounced back. As a result, no idea about the location of nucleus and the presence of empty space in an atom would be available with such a certainty.

Questions:

Q. 1 Name the three subatomic particles of an atom.

Ans.: Electron: It is negatively charged with one unit negative. The mass of an electron is considered to be negligible.

Proton: Proton has a charge, equal in magnitude but opposite in sign to that of the electron. Its mass is considered to be approximately 2000 times as that of the electron.

Neutron: Neutrons are present in the nucleus of all atoms, except hydrogen. It is subatomic particle which had no charge and a mass nearly equal to that of a proton.

Q. 2 Helium atom has an atomic mass of 4u and two protons in its nucleus. How many neutrons does it have?

Ans: We know that atomic mass is numerically equal to mass number of an atom. Since the helium atom has an atomic mass of 4u, therefore, the mass number of helium atom will be 4. And the number of protons in the helium nucleus has been given to be 2. Now,

Mass number = No. of protons + No. of neutrons

$4 = 2 + \text{No. of neutrons}$

And, No. of neutrons = $4 - 2 = 2$

Thus, the helium has 2 neutrons.

Questions:

Q.1 Write the distribution of electrons in carbon and sodium atoms.

Ans: (i) The atomic number of carbon is 6. It means carbon has 6 protons and 6 electrons. Out of these 6 electrons, 2 electrons will occupy the first electron shell which is K shell and the remaining 4 electrons will occupy the second electron shell which is L shell. So, the electron distribution in a carbon atom will be:

K L

2, 4

(ii) The atomic number of sodium is 11. It means sodium atom has 11 protons and 11 electrons in it. Out of these 11 electrons, the first 2 electrons will go to K shell, the next 8 electrons will go to L shell and the remaining 1 electron will go to M shell. So, the electron distribution in a sodium atom will be:

K L M

8, 1

Q. 2 If K and L shells of an atom are full, then what be the total number of electrons in the atom?

Ans: K shell becomes full with 2 electrons and L shell becomes full with 8 electrons. So, if the K and L shells of an atom are full, then it will have a total of $2 + 8 = 10$ electrons in it.

Questions:

Q.1 How will you find the valency of chlorine, sulphur and magnesium?

Ans: The number of electrons gained, lost or shared so as to make the octet of electrons in the outermost shell, gives the combining capacity of the element which is called the valency of an atom.

(i) Valency of chlorine: The Atomic number of chlorine atom is 17. This means it has 17 protons and 17 electrons.

K shell -2, L shell -8 and M shell-7.

A chlorine atom can accept 1 more electron to achieve configuration of 8 valence electrons. The valency of chlorine is 1.

(ii) Valency of sulphur: The atomic number of sulphur is 16. The sulphur atom has 16 protons and 16 electrons. Its electron configuration is K shell-2, L shell- 8 and M shell- 6.

A sulphur atom can accept 2 more electrons to achieve configuration of eight valence electrons. The valency of sulphur is 2.

(iii) Valency of magnesium: The atomic number of magnesium is 12. The means it has 12 protons and 12 electrons.

Its electron configuration is K shell-2, L shell-8 and M shell- 2 .

A magnesium atom can lose 2 outermost electrons to achieve configuration of 8 valence electrons, The valency of magnesium is 2.

Questions:

Q.1 If the number of electrons in an atom is 8 and the number of protons is also 8, then (i) what is the atomic number of the atom? And (ii) what is the charge on the atom?

Ans: (a) Atomic number is equal to the number of protons in one atom. Since this atom contains 8 protons, so the atomic is 8.

b) This atom contains an equal number of positively charged and negatively charged electrons (8 each), so it has no overall charge. That is, the charge on this atom is 0 (zero).

Q.2 With the help of Tab. Is given below, find out the mass numbers of oxygen and sulphur atoms:

Name of Element	Symbol	Atomic Number	No. of Protons	No. of Neutrons	No. of Electron
Oxygen	O	8	8	8	8
Sulphur	S	16	16	16	16

Ans.: The mass number is defined as the sum of the total number of protons and neutrons present in the nucleus of an atom.

(i) Mass number of oxygen

$$= \text{No. of protons} + \text{No. of neutrons} = 8 + 8 = 16$$

Mass number of Oxygen is 16.

(ii) Mass number of sulphur

$$= \text{No. of protons} + \text{No. of neutrons} = 16 + 16 = 32$$

Mass number of sulphur is 32

Questions:

Q. 1 For the symbols H, D and T, tabulate three subatomic particles found in each of them.

Ans: Hydrogen has three isotopes, protium (H^1_1), deuterium (H^2_1 or D^2_1) and tritium (H^3_1 or T^3_1). The chemical properties of isotopes are similar but their physical properties are different. They have same atomic number but different mass numbers.

The three subatomic particles, electrons, protons and neutrons, in the three isotopes of hydrogen are given in the following table:

Isotope	Symbol	Mass number	Atomic number	Number of protons	Number of electrons	Number of neutrons
Hydrogen	H	1	1	1	1	0
Deuterium	D	2	1	1	1	1
Tritium	T	3	1	1	1	2

Q.2 Write the electronic configuration of any one pair of isotopes and isobars.

Ans: (a) A pair of isotopes of chlorine is $^{35}_{17}\text{Cl}$ and $^{37}_{17}\text{Cl}$. The atomic number of both the isotopes is the same 17. So, the electronic configuration of both these isotopes will be 2, 8, 7.

(b) A pair of isobars is $^{40}_{18}\text{Ar}$ and $^{40}_{20}\text{Ca}$. The atomic number of argon (Ar) is 18, so its electronic configuration will be 2, 8, 8. The atomic number of calcium (Ca) is 20, so its electronic configuration will be 2, 8, 8, 2.

Exercise:

Questions:

Q. 1 Compare the properties of electrons, protons and neutrons.

Ans: Comparison between proton, Neutron and Electron

Subatomic particle	Relative mass	Relative charge	Location in the atom
Proton	1u	+1	in the nucleus
Neutron	1u	0	In the nucleus
Electron	1/1840u	-1	Outside nucleus

Q. 2 What are the limitations of J.J. Thomson's model of the atom?

Ans:

1. J.J. Thomson's model of the atom could not explain the results of alpha particle scattering experiment carried out by Rutherford.
2. It also failed to explain the deflections and rebounding of the alpha particles.
3. It also failed to explain an atom's stability.
4. The theory did not mention anything about the nucleus of an atom.

Q.3 What are the limitations of Rutherford's model of the atom?

Ans: Limitations:

- The orbital revolution of the electron is not expected to be stable.
- According to Rutherford's model, the electrons, while moving in their orbits, would give up energy.

Q.4 Describe Bohr's model of the atom.

Ans: The present concept of atom was given by Neils Bohr. The bohr's

model of atom can be described as follows:

- 1) An atom is made up of three particles, called as electrons, protons and neutrons.
- 2) The protons and neutrons are located in a small nucleus at the centre of the atom.
- 3) The electrons revolve rapidly round the nucleus in fixed circular paths called energy levels or shells.
- 4) There is a limit to the number of electrons which each energy level (or shell) can hold.
- 5) Each energy level (or shell) is associated with a fixed amount of energy.
- 6) There is no change in the energy of electrons as long they keep revolving in the same energy level, and the atom remains stable.

Q.5 Compare all the proposed models of an atom given in this chapter.

Ans: A comparison between the models of an atom proposed by J.J. Thomson, Rutherford and Bohr is given below:

Model	Thomson's model of an atom	Rutherford's model of an atom	Bohr's model of an atom
Property	atom in which the atom consisted of a positively charged sphere. The electrons are embedded in the sphere. The negative and the positive charges are equal in magnitude. Hence, the atom is electrically neutral.	Rutherford put forward the model of an atom which had a positively charged center called nucleus. It also had the electrons which revolved around the	i) Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom. (ii) While revolving in discrete orbits the electrons do not radiate energy. (iii) The

		nucleus in well defined orbits.	maximum number of electrons present in a shell is given by the formula $2n^2$ (iv) The maximum number of electrons that can be accommodated in the outermost orbit is 8.
Limitations	J.J. Thomson's model of the atom could not explain the results of alpha particle scattering experiment carried out by Rutherford	he orbital revolution of the electron is not expected to be stable. Any particle which is in a circular orbit would undergo an acceleration. Charged particles would radiate energy during acceleration. Electrons are negatively charged. Thus, the revolving	(i) Heisenberg principle - Position and momentum of a particle cannot be determined at same time, accurately. Result of both of them is greater than $h/4n$. (ii) In Bohr's theory, orbits were circular but now we know that they are 3-D and not 2-D.

		electron would lose energy. It will finally fall into the nucleus. If this was the situation, then the atom should be highly unstable. Hence, matter would not exist in the form that we know.	
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Q.6 Summarise the rules for writing of distribution of electrons in various shells for the first eighteen elements.

Ans:

(1) The maximum possible number of electrons which can be found in any level of the atom of an element is given by $2n^2$ (where n is the number of that energy level). By using this relation, we will find that :

(a) the maximum possible number of electrons which can be accommodated in 1st energy level K shell, where $n=1$,

$2n^2 = 2 \times (1)^2 = 2 \times 1 = 2$. Hence, K shell can have a maximum of 2 electrons.

(b) the maximum possible number of electrons which can be found in 2nd energy level, L shell, where $n = 2$, $2n^2 = 2 \times (2)^2 = 2 \times 4 = 8$. L shell can have a max 8 electrons.

(c) the maximum possible number of electrons which can be found in 3rd energy level M shell, where $n = 3$, $2n^2 = 2 \times (3)^2 = 2 \times 9 = 18$. M shell can have a max 18 electrons.

(d) the maximum possible number of electrons which can be found in 4th energy level N shell, where $n = 4$, $2n^2 = 2 \times (4)^2 = 2 \times 16 = 32$. N shell can have a max 32 electrons.

(2) The electrons in an atom can not occupy a newer shell unless all the inner shells filled with electrons. This means that first, all the electrons fill K shell, then L shell, then M shell, then N shell, and so on.

(3) The electron in the outer shell of the first 18 elements cannot be more than 8 electron in the outermost shell

Q. 7 Define valency by taking the examples of silicon and oxygen.

Ans: In order to achieve an octet in the outermost shell, atoms react. This is done by gaining, sharing or losing electrons. The number of electrons gained, lost or shared so as to make the octet of electrons in the outermost shell, gives the combining capacity of the element which is called the valency of an atom.

Valency of silicon: The atomic number of silicon is 14. It has 14 electrons in its atom. The electronic configuration of silicon atom will be K shell- 2, L shell- 8 and M shell- 4. Silicon has 4 electrons in its valence shell. Now, Silicon atom can neither lose 4 electrons nor gain 4 electrons to complete its the octet due to energy considerations. Hence, silicon atom will share its 4 electrons with the 4 electrons of atoms of other elements to complete its octet. Since one silicon atom will share 4 electrons to achieve inert gas electron arrangement, therefore, the valency of silicon is 4. Valency of oxygen: The atomic number of oxygen is 8. It has 8 electrons in its atom. The electronic configuration of oxygen atom will be

K shell- 2 and L shell- 6. Oxygen has 6 electrons in its outermost shell. Now, an oxygen atom having 6 outermost electrons can gain 2 electrons from some other atom to achieve the nearest noble gas configuration. Since one atom of oxygen can gain 2 electrons to complete its octet. Therefore, the valency of oxygen is 2.

Q. 8 Explain with examples (i) Atomic number (ii) Mass number (iii) Isotopes, and (iv) Isobars. Give any two uses of isotopes.

Ans: (i) Atomic number: The number of protons in an atom of an element is known as atomic number of that element. For example, one atom of sodium element has 11 protons in it, so the atomic number of sodium is 11. Similarly, one atom of carbon element has 6 protons in it, so the atomic number of carbon is 6.

(ii) Mass number: The total number of protons and neutrons present in one atom of an element is known as its mass number. For example, one atom of sodium element contains 11 protons and 12 neutrons. Hence, the mass number of sodium is $11 + 12 = 23$. Similarly, a normal carbon atom has 6 protons and 6 neutrons, so the mass number of carbon is $6 + 6 = 12$.

(iii) Isotopes: Atoms of same element with same atomic number but different mass number are called isotopes of that element. For example, Hydrogen has three isotopes, protium (H^1_1), deuterium (H^2_1 or D^2_1) and tritium (H^3_1 or T^3_1). Many elements consist of a mixture of isotopes. Each isotope of an element is a pure substance. The chemical properties of isotopes are similar but their physical properties are different.

(iv) Isobars: Atoms of different elements which have the same mass number but have different atomic numbers are called isobars. For example, calcium, atomic number-20 and argon, atomic number 18 are isobars. Both these elements have same mass number which is equal to 40. Therefore, the total number of nucleons is the same in both the elements.

Uses of Isotopes: Isotopes of some elements have special properties makes them useful in various fields. For example, (i) An isotope of uranium is used as a fuel in nuclear reactors. (ii) An isotope of cobalt is used in the treatment of cancer. (iii) An isotope of iodine is used in the treatment of goitre.

Q.9 Na^+ has completely filled K and L shells. Explain.

Ans: A sodium ion Na^+ , has 10 electrons in it. Now, the maximum capacity of K shell is 2 electrons and that of L shell is 8 electrons. Taken together, the maximum capacity of K and L shells is $2 + 8 = 10$ electrons. A sodium ion Na^+ has completely filled K and L shells because its 10 electrons can completely fill up K and L shells.

Q.10 If bromine is available in the form of, say, two isotopes $^{79}_{35}\text{Br}$ (49.7%) $^{81}_{35}\text{Br}$ (5.3%) calculate the average atomic mass of bromine atom.

Ans: We know that upper digit in the symbol of an isotope represents its mass (which is the same as its mass number). Now

(i) The mass of $^{79}_{35}\text{Br}$ isotope is 79 u and its abundance is 49.7%.

(ii) The mass of $^{81}_{35}\text{Br}$ isotope is 81 u and its abundance is 50.3%.

So, Average atomic mass of bromine =

$$79 \times \frac{49.7}{100} + 81 \times \frac{50.3}{100}$$

$$= \frac{3926.3}{100} + \frac{4074.3}{100}$$

$$= 39.263 + 40.743$$

$$= 80.006$$

$$= 80\text{u}$$

Thus, the average atomic mass of bromine is 80 u.

Q.11 The average atomic mass of a sample of an element X is 16.2 u. What are the percentages of isotopes $^{16}_8\text{X}$ and $^{18}_8\text{X}$ in the sample.

Ans.:

In order to solve this problem, we will have to suppose that the percentage of one of the isotopes in the sample is x, so that the percentage of the other isotope in the sample will be (100-x). Now:

(i) The mass of $^{16}_8\text{X}$ isotope is 16u. Suppose its percentage in the sample is x%.

(ii) The mass of $^{18}_8\text{X}$ isotope is 18 u. Its percentage in the sample will be (100-x)%.

$$\text{So, Average atomic mass of X} = 16 \times \frac{x}{100} + 18 \times \frac{(100-x)}{100}$$

But the average atomic mass of X has been given to be 16.2 u. Therefore,

$$16.2 = 16 \times \frac{x}{100} + 18 \times \frac{(100-x)}{100}$$

$$16.2 = \frac{16X + 1800 - 18x}{100}$$

$$16.2 \times 100 = 1800 - 2x$$

$$2x = 1800 - 1620$$

$$2x = 180$$

$$x = \frac{180}{2}$$

$$X = 90$$

Thus, the percentage of the ^{16}X isotope in the sample is 90%. The percentage of the isotope ^{18}X in the sample will be $100 - 90 = 10\%$.

Q.12 If $Z = 3$, what would be the valency of the element? Also name the element.

Ans: The symbol Z stands for the atomic number of an element. By saying that $Z = 3$, we mean that the atomic number of this element is 3. The electronic configuration of the element having atomic number 3 is K L 2, 1. It has 1 electron in its outermost shell (L shell). So, one atom of this element can lose 1 electron to achieve the nearest inert gas electron arrangement of K (which is the same as that of helium gas). Since one atom of this element loses 1 electron to achieve the inert gas electron configuration, therefore, its valency is 1. The element having atomic number 3 is lithium.

tamso ma jyotirgamaya

Q. 13 Composition of the nuclei of two atomic species X and Y is given as under:

X Y

Protons = 6 6

Neutrons = 6 8

Give the mass numbers of X and Y. What is the relation between the two species?

Ans.: We know that:

Mass number = No. of protons + No. of neutrons

So, Mass number of X = 6 + 6

= 12

Mass number of Y = 6 + 8

= 14

Thus, the mass number of X is 12 and that of Y is 14.

Q. 14 A For the following statements, write T for true and F for false:

J. J. Thomson proposed that the nucleus of an atom contains only nucleons.

Ans.: False.

J.J Thomson proposed the model of an atom in which the atom consisted of a positively charged sphere. The electrons are embedded in the sphere. The negative and the positive charges are equal in magnitude.

Q.14(B) For the following statements, write T for true and F for false:

A neutron is formed by an electron and a proton combining together. Therefore, it is neutral.

Ans.: False.

Neutrons are present in the nucleus of all atoms, except hydrogen. It is subatomic particle which had no charge and a mass nearly equal to that of a proton.

Q. 14C For the following statements, write T for true and F for false:

The mass of an electron is about $1/2000$ times that of a proton.

Ans.: True.

Proton has a charge, equal in magnitude but opposite in sign to that of the electron. Its mass is considered to be approximately 2000 times as that of the electron.

Q. 14D For the following statements, write T for true and F for false:

An isotope of iodine is used for making tincture iodine, which is used as a medicine.

Ans.: False

An isotope of iodine is used in the treatment of goitre.

Q.15 Rutherford's alpha-particle scattering experiment was responsible for the discovery of:

- (a) Atomic nucleus (b) Electron
- (c) Proton (d) Neutron

Ans: (a) Atomic nucleus

According to the Rutherford's model of an atom, there is a positively charged center called nucleus. Almost all the mass of an atom resides in the nucleus. The electrons revolve around the nucleus in well defined orbits which can be compared to the solar system.

Q. 16 Isotopes of an element have :

- (a) the same physical properties
- (c) different number of neutrons
- (b) different chemical properties
- (d) different atomic numbers

Ans: (c) different number of neutrons.

Atoms of same element with same atomic number but different mass number are called isotopes of that element. For example, Hydrogen has three isotopes, protium (H^1_1), deuterium (H^2_1 or D^2_1) and tritium (H^3_1 or T^3_1).

Q. 17 Number of valence electrons in Cl^- ion are:

- (a) 16
- (b) 8
- (c) 17
- (d) 18

Ans:



Chlorine atom with 17 protons(+) and 17 electrons (-) Charge =0

Chloride ion with 17 protons (+) and 18 electrons (-) Charge = -1.

Q. 18 Which of the following is a correct electronic configuration of sodium?

- (a) 2, 8 (b) 8, 2, 1
(c) 2, 1, 8 (d) 2, 8, 1

Ans: (d) 2, 8, 1

Atomic number of sodium is 11. Its electronic configuration is K shell- 2, L shell- 8 and m shell- 1. It has 1 electron in its valence shell.

Q. 19 Complete the following table:

Atomic Number	Mass number	Number of neutrons	Number of protons	Number of electrons	Name of the atomic species
9	-	10	-	-	-
16	32	-	-	-	Sulphur
-	24	-	12	-	-
-	2	-	1	-	-
-	1	-	1	0	-

Ans.:

(a) First row:

- (i) The given atomic number is 9. This shows that the number of protons is 9 and the number of electrons is also 9.
(ii) Mass number is equal to the sum of the number of protons and neutrons. Therefore, mass number = $9 + 10 = 19$.
(iii) The atomic species having atomic number 9 is fluorine.

(b) Second row:

- (i) The given atomic number is 16. This shows that the number of protons is 16 and the number of electrons is also 16.

(ii) The given mass number is 32. Number of neutrons can be calculated as , Mass number minus the number of protons. Therefore, the number of neutrons = $32 - 16 = 16$

(c) Third row:

(i) The number of protons as 12. Hence, the atomic number is 12. The number of electrons is also equal to 12.

(ii) Number of neutrons can be calculated as, Mass number minus the number of protons. Therefore, the number of neutrons = $24 - 12 = 12$.

(iii) The atomic species with atomic number 12 is magnesium.

(d) Fourth row:

(i) The number of protons is given as 1. Hence, the atomic number is 1 and the number of electrons is also equal to 1.

(ii) Number of neutrons can be calculated as, Mass number minus the number of protons. Therefore, the number of neutrons = $2 - 1 = 1$.

(iii) The atomic species of atomic number 1 and mass number 2 is an isotope of hydrogen called deuterium H^2_1 or D^2_1 .

(e) Fifth row

(i) The number of protons is given as 1. Hence, the atomic number is also 1.

(ii) The atomic species of atomic number 1 and mass number 1 is hydrogen or protium.

We can now write the completed Table as follows:

Atomic number	Mass number	Number of neutrons	Number of protons	Number of electrons	Name of the atomic species
9	19	10	9	9	Fluorine

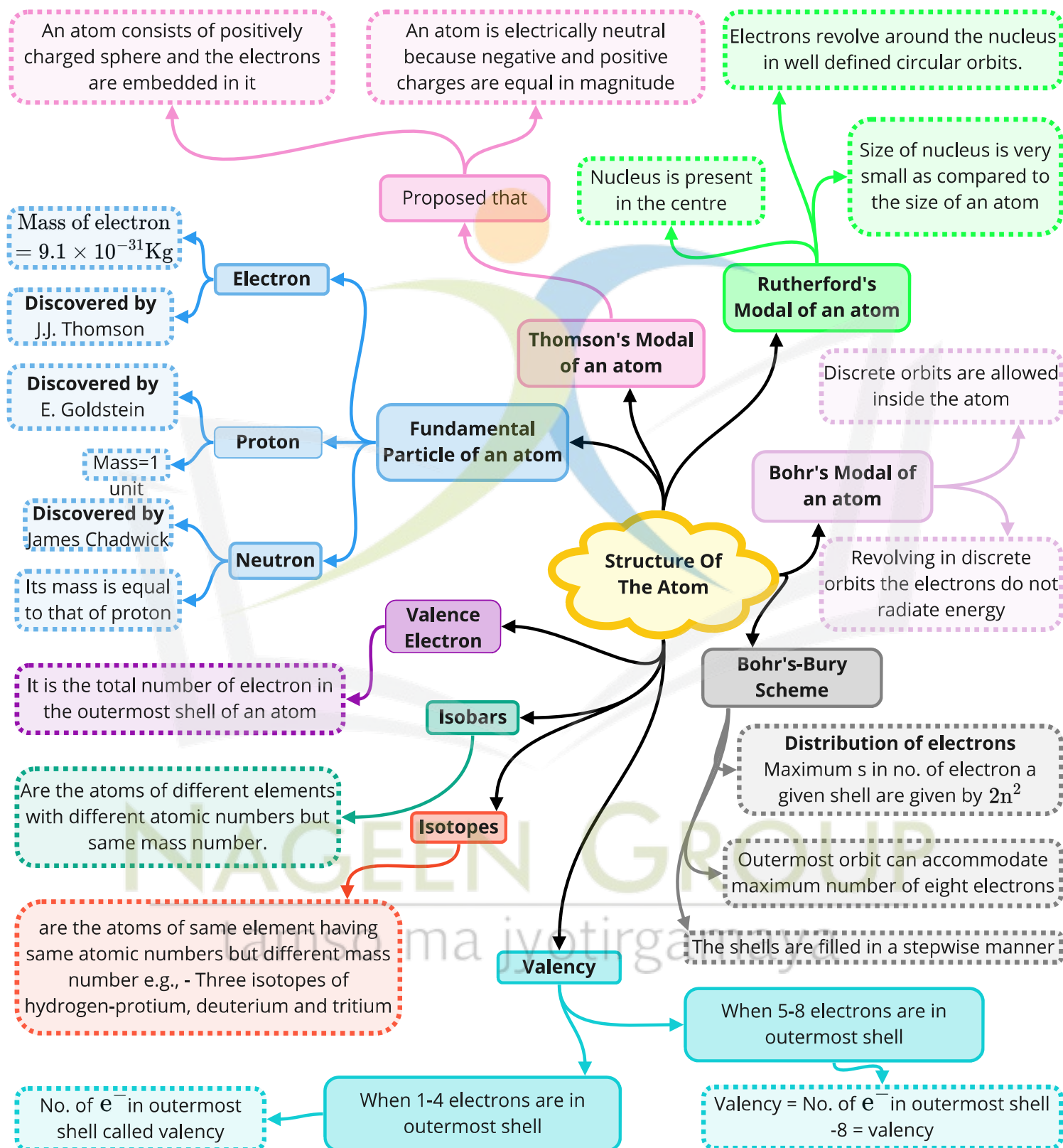
16	32	16	16	16	Sulphur
12	24	12	12	12	Magnesium
1	2	1	1	1	Deutrium
1	1	0	1	0	Protium (hydrogen)



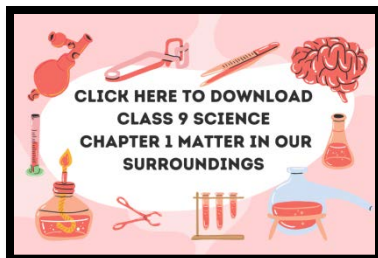
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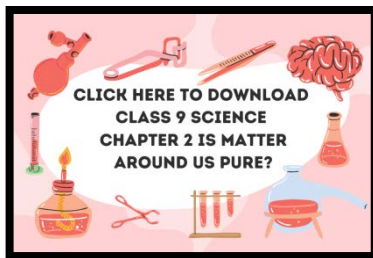
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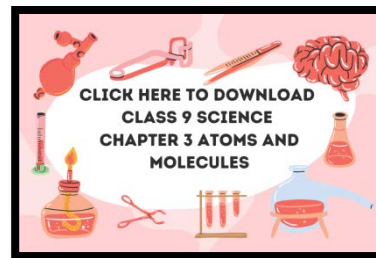
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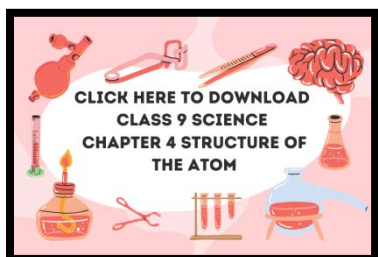
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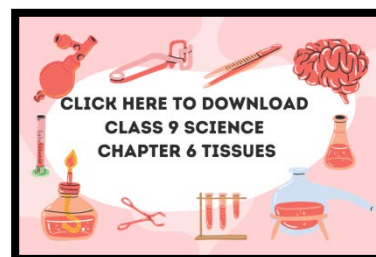
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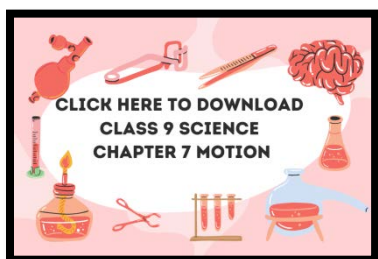
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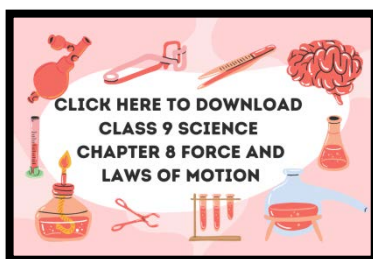
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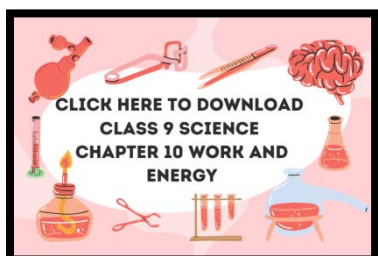
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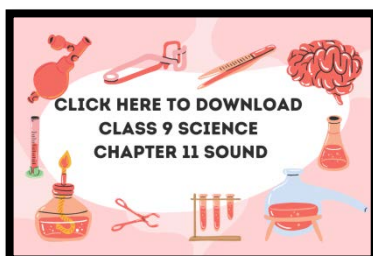
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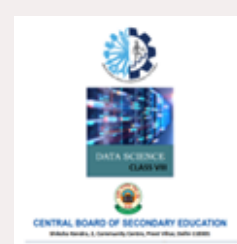
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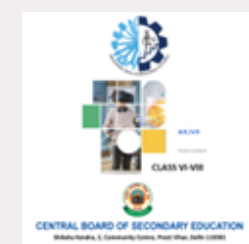
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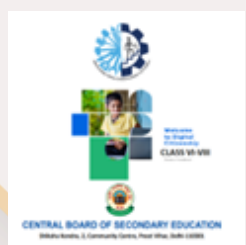
Coding



Data Science (Class VIII
only)



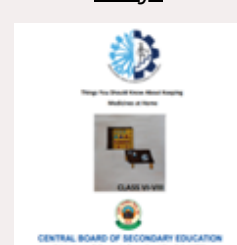
Augmented Reality /
Virtual Reality



Digital Citizenship



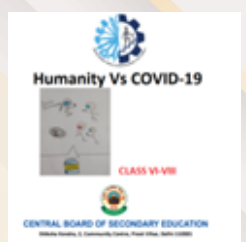
Life Cycle of Medicine &
Vaccine



Things you should know
about keeping Medicines
at home



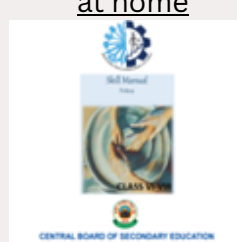
What to do when Doctor
is not around



Humanity & Covid-19



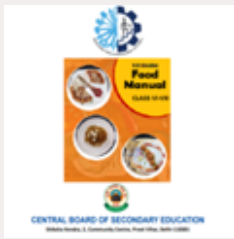
Blue Pottery



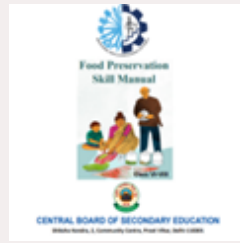
Pottery



Block Printing



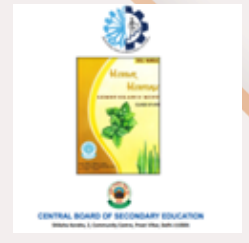
Food



Food Preservation



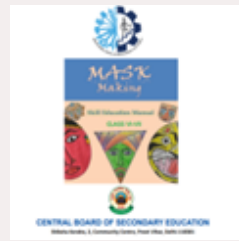
Baking



Herbal Heritage



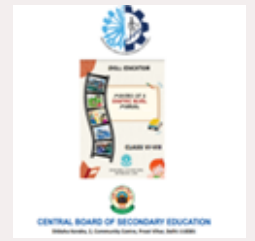
Khadi



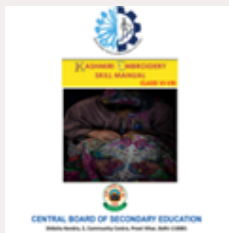
Mask Making



Mass Media



Making of a Graphic Novel



Kashmiri Embroidery



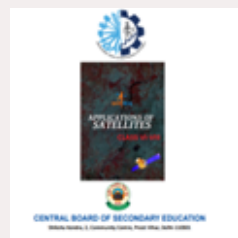
Embroidery



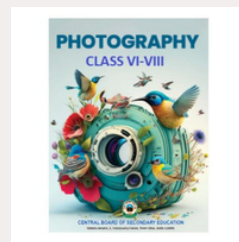
Rockets



Satellites

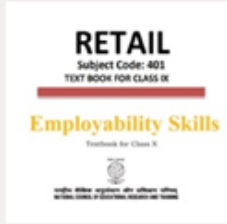


Application of Satellites

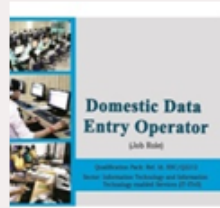


Photography

SKILL SUBJECTS AT SECONDARY LEVEL (CLASSES IX – X)



Retail



Information Technology



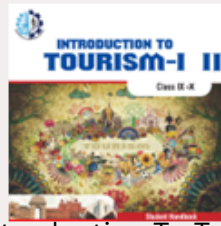
Security



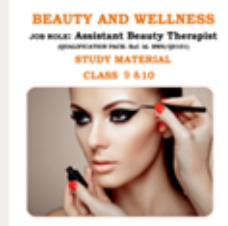
Automotive



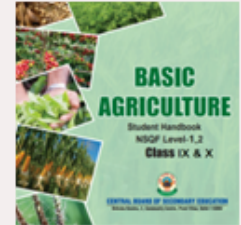
Introduction To Financial Markets



Introduction To Tourism



Beauty & Wellness



Agriculture



Food Production



Front Office Operations



Banking & Insurance



Marketing & Sales



Health Care



Apparel



Multi Media



Multi Skill Foundation Course



Artificial Intelligence



Physical Activity Trainer



Data Science



Electronics & Hardware (NEW)

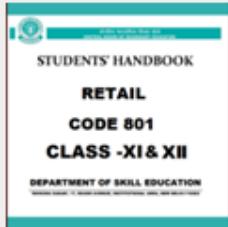


Foundation Skills For Sciences (Pharmaceutical & Biotechnology)(NEW)

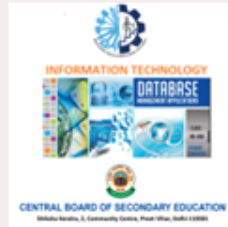


Design Thinking & Innovation (NEW)

SKILL SUBJECTS AT SR. SEC. LEVEL (CLASSES XI – XII)



Retail



Information Technology



Web Application



Automotive



Financial Markets Management



Tourism



Beauty & Wellness



Agriculture



Food Production



Front Office Operations



Banking



Marketing



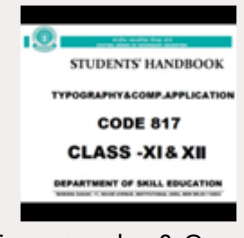
Health Care



Insurance



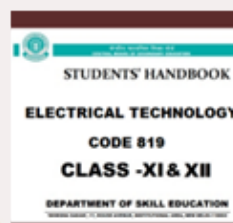
Horticulture



Typography & Comp.
Application



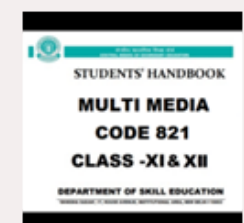
Geospatial Technology



Electrical Technology



Electronic Technology



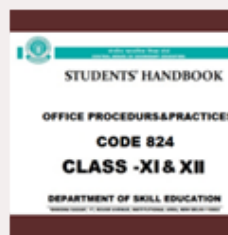
Multi-Media



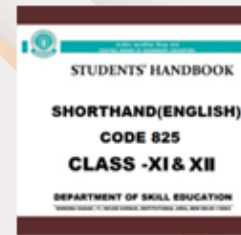
Taxation



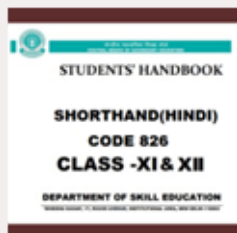
Cost Accounting



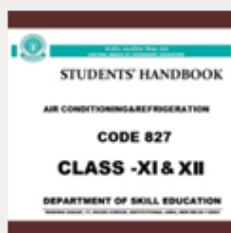
Office Procedures & Practices



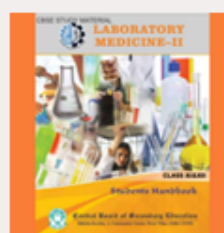
Shorthand (English)



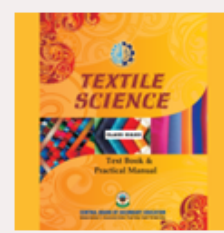
Shorthand (Hindi)



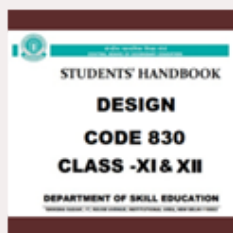
Air-Conditioning & Refrigeration



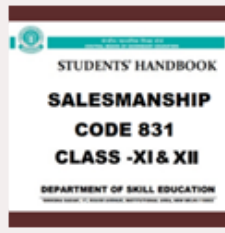
Medical Diagnostics



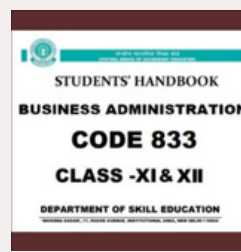
Textile Design



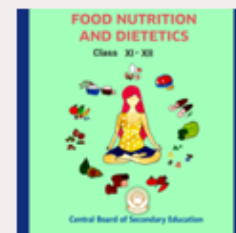
Design



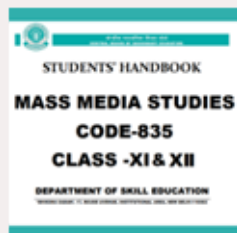
Salesmanship



Business Administration



Food Nutrition & Dietetics



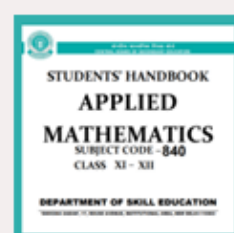
Mass Media Studies



Library & Information Science



Fashion Studies



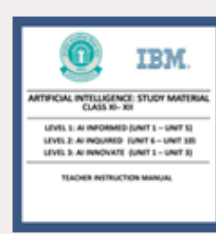
Applied Mathematics



Yoga



Early Childhood Care & Education



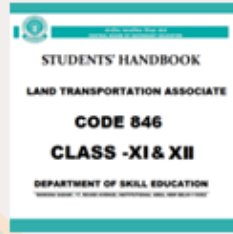
Artificial Intelligence



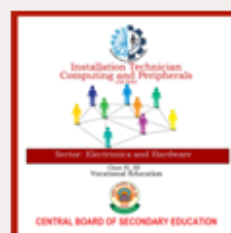
Data Science



Physical Activity Trainer(new)



Land Transportation Associate (NEW)



Electronics & Hardware (NEW)



Design Thinking & Innovation (NEW)

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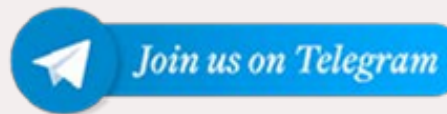
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Class 3



Class 4



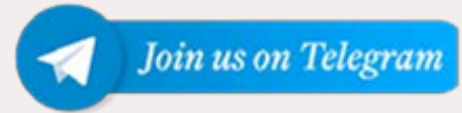
Class 5



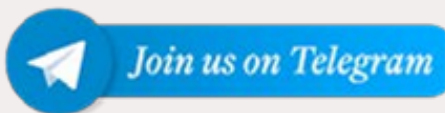
Class 6



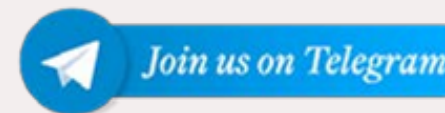
Class 7



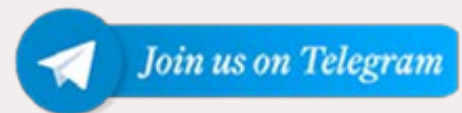
Class 8



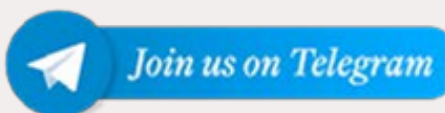
Class 9



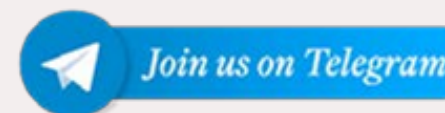
Class 10



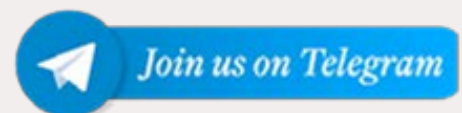
Class 11 (Sci)



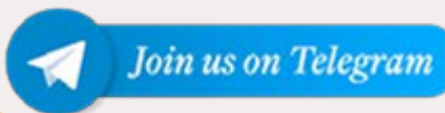
Class 11 (Com)



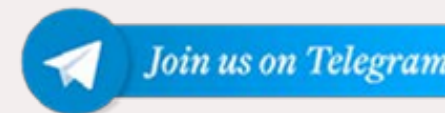
Class 11 (Hum)



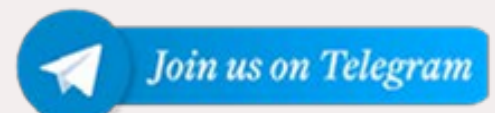
Class 12 (Sci)



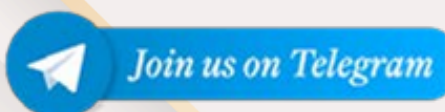
Class 12 (Com)



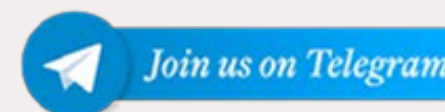
Class 12 (Hum)



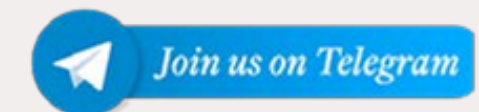
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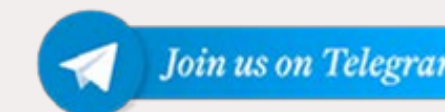
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